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SCHOOL OF ECONOMICS AND BUSINESS

MASTER'S THESIS

AN ANALYSIS OF THE AGEING POPULATION EFFECTS ON MONETARY POLICY

Ljubljana, April 2023 DOROTEJA ČAHUK

AUTHORSHIP STATEMENT

The undersigned Doroteja Čahuk, a student at the University of Ljubljana, School of Economics and Business, (hereinafter: SEB LU), author of this written work of studies with the title **An analysis of the ageing population effects on monetary policy**, prepared under the supervision of **Professor Igor Masten PhD**.

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LIST OF ABBREVIATIONS

3Ds Debt, demographics and distribution of income

DNK Dynamic New Keynesian framework

FOC First order condition

GDP Gross domestic product

LAB Learning against the bubble

MY Middle-aged to young ratio

ZLB Zero lower bound

INTRODUCTION

In the past 150 years, humanity achieved great success in longer life expectancy, which increased the most in developed countries all around the world. Comparing the 30 years of life expectancy then, with today's one, which is 73 years and is still rising, we can see that great achievements have been done in the field of living. However, despite all the positive things that longer life expectancy can bring to the economy, there exist many negative effects of this demographic change on the economy as a whole (Scoot, 2020). The ageing of the population can therefore be understood as a result of the economic development of each country and the world as a whole. In the second half of the 20th century, when many of the world's economies became more developed, life expectancy started to increase, and on the other hand, the fertility rate started to decrease, leading to the ageing of the population over time (Batini & McKibbin, 2006). Together with three other mega trends (population growth, urbanization, and international migration), that characterize the global population today, population ageing is representing one of the main challenges of the global economy (United Nations, 2020). Due to higher economic development, global population growth started to decrease, leading to additional pressure in the fields of labor, economic growth and finance in advanced economies. To avoid such negative effects of population ageing, a rapid response of economic policies to the presented phenomenon within society is crucial. Many countries have already done a lot in the direction of differently designed policies, which include the phenomenon of population ageing, and they are also trying to turn them to the benefit of their economies (Batini & McKibbin, 2006).

In 2021 around 9.3% (727 million) of the world's population was 65 or more years old. Research and forecasts show that in 2050 this number will increase to 16% of the world population, and 1.5 billion people will be 65 or more years old (WHO, 2021). Just for the European Union (hereinafter: EU) population is projected to fall, accompanied by a drastic change in its population structure. It is calculated that the share of the EU's older population compared to the younger population will rise to 30% by 2070 in most EU countries, leading to macroeconomic, financial and medical problems in many countries, if proper policy changes will not apply (European Commission, 2020).

The changed age structure of the population in countries around the world will require quick and thoughtful macroeconomic policy measures to reduce the effects of this demographic phenomenon. Japan, the country with the oldest population, has done many things in order to fight these population ageing effects on the economy. Due to the high population ageing of the Japanese population after 1990, the country has suffered from a major demographic crisis ever since. But after all, they took all the opportunities of this demographic process, which lead to big digitalization of their economy and changing labor market. Additionally, Japan also changed its fiscal policy and monetary policy, to mitigate these negative effects of the population ageing on their economy. By implementing the so-called age-tech into their economy, they were able to overcome the

negative effects of the population ageing problem. Precisely because of such a good and successful response to the presented problem of population ageing, Japan is considered to be one of the top leaders in dealing with the population crisis. For many economies facing the same problems of population ageing, it thus gives hope that a powerful economy can be developed and maintained even in the case of an ageing population (European Parliament, 2020). The same responses are visible in the second oldest country in the world, Italy, and also in Finland, where digitalization and reforms of the public finance system are representing the major changes in order to fight against the negative effects of population ageing (Mazzola et al., 2015; Mäki-Fränti, Kliponen & Kinnunen, 2015).

Population ageing is, thus, considered to be one of many fears of more developed countries. The changed structure of the population that, due to a longer life expectancy and a lower fertility rate is much more inclined to an inverted image of the pyramid, requiring quite a few adjustments of the entire economic system. If we focus only on the effects of the ageing population on monetary policy, we can find evidence in various authors' previous research confirming, the ageing of the population reflects a strong imprint on the management and the operation of the monetary policy. Normally, the effects of population ageing on monetary policy proceed through five channels. Due to the changed spending and saving habits of the older population, which watches its consumption much more carefully and thus devotes more money to saving in order to have a better life in the future, the negative effects of the ageing population can be detected in monetary policy. Smoother planning and scheduling of consumption and saving habits of people in the elderly population results in a smaller response of the population to monetary policy shocks. This connection was proved by many economists, saying that the older population reacts worse to monetary policy shocks, leading to decreased effectiveness of monetary policy in a certain economic environment. In accordance with the changed consumption and saving habits of the elderly population, the effects of the presented demographic problem on monetary policy can also take place through the channel of wealth and credit. It is known that the population's wealth will improve significantly due to the ageing of the population. This follows from the life cycle hypothesis claiming, that the young agents are known as borrowers and the old agents are known as lenders. Relationships between young and old agents, thus, follow the mechanism, where young people borrow their money from the old agents, while old agents lend their saved money to the young people. Changed distribution of money throughout the life period of the older population will, therefore imply many, positive and negative, effects on the monetary policy and its effectiveness. The life cycle hypothesis claims, that the young agent's consumer habits are much more different from those of the older population. Since the consumption of younger agents will be bigger, despite their monthly income, they will need some extra money to fulfill their consumption patterns. Young agents will, therefore, borrow some money from the old agents since they will have some excess money, due to smaller consumption and different consumer habits.

Young agents will use their borrowed money to finance their consumption, but at the same time, they will allocate one part of that money into investments that will bring them positive returns in the future. When these young agents will reach their old retirement age, they will shift from being the borrower to the lenders. Due to their changed consumption patterns and the positive returns from the investments made at young age, they will have some excess money they will lend to the younger part of the population. Following this life cycle hypothesis, we can see that older people will hold more money, leading to higher deposits at banks, accompanied by higher savings rates. Since banks will gain additional money from the higher deposits of old agents, the higher credit supply will be noticeable, possibly leading to positive effects on inflation and savings rate. Higher inflation accompanied by higher savings rates in the older population will therefore require a change in the monetary policy, which will have to react more aggressively to the changes in the inflation rate. Together with the higher inflation rate, the ageing of the population will also affect the monetary policy and its effectiveness through the channel of interest rates, where many negative effects can be detected. Due to the changed consumer preferences of older people who will prefer low and stable inflation that will preserve the value of their saved money, the negative effects on the natural rate of interest and the real interest rate may be detected. Additionally, the probability of hitting the Zero-Lower Bound (hereinafter: ZLB) will be much higher in the case of the older population. The higher probability of hitting the ZLB, together with the negative effects on the natural rate of interest and the real interest rate, can lead to a weaker monetary policy response to different economic shocks, leading to the lost credibility and smaller efficiency of the monetary policy (Baksa & Munkacsi, 2019).

The key idea of my thesis is to find whether population ageing can affect monetary policy and its efficiency. Due to the big negative effects of population ageing on other macroeconomic indicators, I asked myself whether monetary policy can be affected as well through changes in population behavior in the economy. In my thesis, I will focus on the population ageing impact on monetary policy through the calculations of the Dynamic New Keynesian (hereinafter: DNK) model with overlapping generations.

The purpose of the thesis is to show how the ageing of the population can affect monetary policy. Changed consumption and savings patterns of the older population will lead to a change in inflation and interest rate, posing a challenge to monetary policy. The purpose of my master's thesis is also to show the consequences of population ageing on the effectiveness of the monetary policy. I will focus on the investigation of the effects of population ageing on different channels in the economy that, will then affect monetary policy and its efficiency. In my master's thesis, I will try to answer the following hypothetical questions:

- Does the ageing of the population lead to negative effects on monetary policy?

- How will the ageing of the population affect inflation and the interest rate in the economy?

- Will monetary policy efficiency be smaller in the case of an ageing population economy?

In this thesis, I investigate the effects of population ageing on monetary policy through different channels in the economy. Changes in the agents' behavior that, are even more pronounced in the process of the ageing of the population represent a major problem in the functioning of the entire economy. In my master's thesis, I described five economic channels through which population ageing effects will be transferred to monetary policy and its effectiveness. Negative effects of population ageing can be visible in the field of savings rates, and in the aggregate consumption response to the monetary policy shock. The effects of population aging can also be detected through the interest rate and inflation channels. According to the literature, the ageing of the population can have a negative effect on the formation of interest rates, as well as it can put downward pressure on the inflation rate. In my master's thesis, I also looked at the effects of population ageing through wealth and the credit channel. Population ageing will increase the importance of these two channels mostly due to the higher wealth and larger savings of older people. All of the above, thus, represents one of the challenges of monetary policy because due to the presented effects, it can find itself in front of great restrictive possibilities. To study these effects of population ageing on monetary policy, I used the simple DNK model with overlapping generations to calculate the impulse responses to the tightening monetary policy shock in two economies, one with a young population and one with an old population. Using Matlab and Dynare I compare the impulse responses of these two different populations to see whether population ageing can have negative effects on monetary policy and its efficiency.

My findings showed that population ageing can really affect monetary policy and its efficiency in a negative way. Due to population ageing, the natural rate of interest will decrease and the effectiveness of monetary policy following the output gap will become less effective. All this will happen due to the smaller interest rate sensitivity of older agents, which will happen due to the changed savings pattern of these agents. Lastly, the sacrifice ratio between inflation and output will decrease, meaning that the new conducting of monetary policy, which contains the effects of ageing of the population, will be needed.

The thesis is structured as follows. The first chapter briefly describes the effects of population ageing on economic growth and public finances together with fiscal policy. The second chapter provides the effects of population ageing on monetary policy through the five different channels, i.e., the consumption channel, savings channel, wealth and credit channel, interest rate channel, and inflation channel. Additionally, this chapter also describes population ageing effects on monetary policy and its efficiency. Chapter three

provides the two-period DNK model with overlapping generations. First, the demand and the supply side of the economy is shown, following the equilibrium conditions and the log linearization of the model. In the last chapter, Chapter 4, we find the analysis of the population ageing effects on the monetary policy, comparing the impulse responses of the populations with different age structures. Results and concluding remarks are described in the conclusion at the end of the thesis.

THE EFFECTS OF POPULATION AGEING ON MACROECONOMIC INDICATORS

Economies worldwide are nowadays facing many problems that question the stability of basic macroeconomic policies. Due to the last financial crisis in 2008 and many economic problems today, most countries are facing the negative effects of the presented shocks on their public finance sustainability and economic development. Together with all sorts of economic and financial shocks, population ageing is starting to represent one of the most important features for the future development of advanced economies.

The population in advanced economies is getting older and older, leading to many problems in the economy. The effects of a big baby boom generation born between 1950 and 1970 are starting to appear in many macroeconomic indicators, such as economic growth, saving and investment rates, public finances, and others. Together with slower population growth and lower fertility rates in most advanced economies, these effects of ageing are becoming even more visible and more effective.

People in advanced and developed countries are living longer, which is somehow connected to the better economic development of these countries. It is known that economies through their development are starting to increase the living standard of their population, which then leads to longer life expectancy. On the other hand, due to this better economic development, fertility rates are starting to decrease in these economies, mostly due to the longer education and later entering the labor market. Connected to that dependency ratios, the ratio between people over 65 years to people aged between 14-65 years, these people are starting to increase in the ageing population as well. The group of top major economies (the G-20 group) has been suffering from falling population growth and a rising dependency ratio since 1970. Together with a lower fertility rate and problems connected to the migration of people, many problems started to occur in their economies, leading to some important policy changes in order to mitigate the impact of this demographic shock (International Monetary Fund, n.d.).

We can say that increasing life expectancy and decreasing fertility rates are, therefore, leading to population ageing, which generally will have a major impact on macroeconomic policies if required reforms or changes will not be applied. The problem of this “demographic time bomb” (longer life expectancy together with lower fertility rate) can put big problems, especially in the fields of the labor market, gross domestic

product (hereinafter: GDP) growth, and public finance sustainability (Pettinger, 2019). Lee & Manson (2017) added that the ageing of the population can additionally affect the economies through the rise in the amount of capital per worker and, that due to the negative effects of population ageing on GDP, countries may face stagnation of their economy as well.

Many economists of the countries struggling with this population ageing show that with the required policy response and incorporation of it into the policy-making the effects of this population ageing on the economy can be reduced. Reforms in many policies accompanied by better global risk-sharing and international cooperation between countries, can therefore play a key role in mitigating some of these negative macroeconomic effects of ageing (International Monetary Fund, n.d.).

1.1 Population Ageing and the GDP

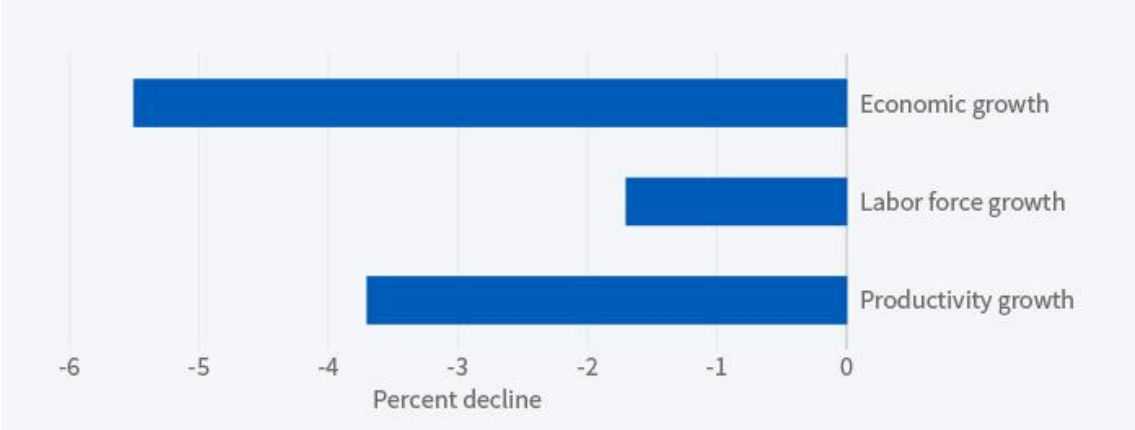
Rising dependency ratios in ageing economies can have a big negative effect on GDP per capita growth. These negative effects are mostly happening due to the problem of the missing workforce in the labor market. In each ageing economy, the number of older people is rising and the number of younger ones is starting to decrease, leading to negative effects on population growth. Through the ageing process, more and more workers are starting to leave the labor market, leading to a sharp increase in the number of retired workers compared to the remaining workforce. Due to the higher number of retired workers and the lower number of remaining workers on the labor market, the economy falls into the problem of the missing workforce that, can negatively affect its overall productivity. Fewer workers on the labor market can, therefore, lead to lower labor input and lower productivity which, can furthermore lead to a decline in aggregate potential output. Additionally, when fewer and fewer workers will remain in the labor markets, the supply of the labor force will decline, leading to an increase in the real wage (International Monetary Fund, n.d.).

Adam Smith already spoke about this connection between population growth and economic growth. He claimed that the higher population growth will lead to higher economic growth and, expansion, mostly due to the widening of the market connected to a bigger share of the workforce population. Therefore, a bigger labor supply will lead to higher production, pushing economic growth up again. Concluding his words, we can say that population ageing will negatively affect population growth due to a smaller share of workers and smaller labor supply, leading to smaller production and lower GDP (Hansen, 2004, pages 331-332).

It has been calculated that ageing will put downward pressure on the GDP per capita growth by on average 0.4 to 0.5%. If a certain economy wants to eliminate these negative effects of ageing on GDP per capita growth, there needs to be an increase in the overall productivity by at least 0.4% or 0.5% to offset the ageing effects. Higher productivity can

be achieved in many ways, among which the most successful are those related to the better migration policy and greater investment in the technological development of the whole production sector (International Monetary Fund, n.d.). Maestat, Mullen & Powell (2022), came to similar results, which proved that the 10% increase in the fraction of people aged 60 or more will lead to a decrease in the GDP per capita by 5.5%. The results of their analysis of the negative population ageing effects on economic growth, labor-force growth, and productivity growth can be visible in Figure 1. They explained that the decline in GDP per capita will occur for two reasons. Deteriorating labor force growth will be responsible for the first third of the decline that, will become much scarcer as the workforce shrinks. For the remaining two-thirds, the gradual decrease in productivity growth will be responsible, which coincides with the smaller labor force on the market.

Figure 1: Effect of a 10% increase in the share of population aged 60 and over



Source: Maestas, Mullen & Powell (2022).

Another way to make this negative effect of population ageing on the GDP less effective is connected to the higher number of older workers in the labor force. It has been shown that if the country has such a working policy, in which older workers can work for a longer period, this can have a major positive effect on GDP growth. This response can be understood by examining the response of taxes paid by workers. A larger share of older workers in the labor markets will have a positive effect on the labor supply, and due to smaller transfers related to pensions, it will also have a positive effect on the after-all tax burden of the individual worker. It is known that in the case of higher expenditures of public finances intended for the payment of pensions for the elderly, there is an increase in taxes used to finance these pensions transfers. In case a certain share of the elderly population returns or remains on the labor market, this means a lower burden on the pension system, and consequently, a lower tax burden on the individual worker. Furthermore, a higher share of older workers will have a positive effect on productivity, and due to lowered tax burden, the consumption of the working population will be positively affected, leading to higher GDP growth (Yoshino & Miyamoto, 2019).

Another possible reduction of this effect on GDP is to improve labor migration. In case the number of older workers does not change, or they no longer remain on the labor market, the country can acquire the missing labor force through labor migration (International Monetary Fund, n.d.). European Central Bank (n.d.a) added, that with a better investment and innovation policy by the firms, additional positive effects on the GDP can be achieved in the ageing population society.

1.2 Public Finances and Fiscal Policy

As we could see by now, population ageing is a challenge for the majority of the policies in the economy. The most affected are definitely the public finances and their sustainability. High levels of public debt combined with increasing public pension liabilities can put a major risk on the sustainability of public finance and, therefore, leave little room for fiscal policy response (European Central Bank, n.d.a).

Many developed countries are already dealing with the problems of the stability of the pension system. Pay-as-you-go pension systems are often the target of instability due to the lower proportion of working people who fill the public funds through paid transfers, which are then largely redistributed to the older generation in the form of pensions. Due to the declining share of the working population compared to the elderly population, contributions to public funds are becoming too small to pay the pensions of the older generation. The deficit of the public treasury on the revenue side forces many countries suffering from the problem of aging populations to raise taxes or other transfers or simply reduce the amount and size of public expenditure intended for the pensions' payments. Therefore, the stability of the pension system and the stability of the whole public finance are becoming one of the main topics connected to policy-making in the last few years (McMorrow & Roeger, n.d.).

In addition to the problem of the pension system, increasing health-care costs positively correlated with an increasing life expectancy and ageing population will also be a major problem for public finances. People will live longer meanings their health will need to be taken care of for a longer period of time. Age-related illnesses occurring in the later years of life and requiring a large financial bite will, thus, represent additional pressure on the stability of the public finance system (International Monetary Fund, n.d.).

Yoshino & Miyamoto (2019) showed the impact of population ageing on fiscal policy and its power to influence. They analyze the output effects of government spending using two different countries, one with a high share of the young generation and one with at high share of the old generation. In the case of the younger generation, positive government spending shock increased output by about 0.3% in the same year and 1.5% in the medium term. In contrast, in the old economy, the response of output was not statistically significant, showing that the macroeconomic impacts of fiscal policy shocks are weakened when population ageing occurs.

Ageing will have a deep impact on public finances and government fiscal policy. The increase in public finance expenditures used for pensions and health-care, will, thus remain under the watchful eye in countries with an ageing population problem. Reforms in the fields of public finance and fiscal policy will, therefore, represent a common practice in ageing economies. It has been proved that if fiscal policy and public finance policy do not react, the stability of these can fall sharply due to an increase on the expenditure side. With the correct and thoughtful reaction to the presented policies, the effects of the ageing population problem on public finances and fiscal policy, can be mitigated and put under control (European Central Bank, n.d.b).

2 IMPACT OF POPULATION AGEING ON MONETARY POLICY

In the previous chapter, we found that population ageing can have a major impact on the economy and its policies. Ageing of the population can lead to a lower labor supply and to a reduction in the GDP per capita growth. The effects of population ageing are today most visible in the area of fiscal policy, where they represent a considerable challenge in maintaining the stability of public finances. In addition, the effects of population ageing can also be visible within monetary policy, where they can have a negative impact on the functioning of monetary policy through various channels.

Vlieghe (2016) talks about the famous 3Ds (debt, demographics and distribution of income) that can lead to an unstable economic environment. One of them is demographic, which can lead to slower economic growth due to slower population growth. The effects of population ageing can persist for decades, leading to many problems in an economic environment. The most noticeable effects of population ageing will be seen in the field of interest rates and savings. Especially the interest rate channel will, therefore, play an important role in explaining what impact ageing will have on monetary policy and its efficiency.

As we can see by now, population ageing will change policies and their stability if there is no action. This chapter will look into the connection between monetary policy and population ageing to find out, whether this policy will also be affected by this demographic shock. First, we are going to look at the consumption channel in connection to monetary policy, followed by the savings channel, wealth and credit, interest rate, and inflation channel. Lastly, we are going to look at the connection between population ageing and monetary policy and its efficiency.

2.1 Consumption Channel

There are many written papers studying the relationship between age structure and consumption patterns. Most of them are concluding with the same results, saying that

with the ageing of the population, aggregate consumption response to monetary policy shock will be weakened, due to the smaller consumption response of the older population.

According to the life cycle hypothesis, a large share of middle-aged people will be responsible for higher savings rates in the economy. In Finland, this consumption response to monetary shock is somehow connected to the household margin. The household margin represents the money we have after we pay all our standard expenses. A monetary policy shock can lead to consumption changes through the credit channel connected to income and wealth. In the case of a smaller household margin, consumption response to monetary policy shock will be higher than in the case of a bigger household margin. If we calculate the general equilibrium stimulations, it has been found that lower consumption response to a monetary policy shock will be notable in the older population. This negative relationship will be connected to the fact that late middle-aged people and older people already know that their retirement age will be longer, which leads them to higher consumption smoothing over the remaining life period. They will smooth out their consumption, causing s smaller consumption response to the monetary policy shock (Mäki-Fränti, Kliponen & Kinnunen, 2015).

If we look at the response of households to a monetary policy shock, there is clear evidence that the younger population's consumption will react strongly compared to the older one. The younger population will reduce expenditure more when a monetary policy shock will occur. On the other hand, the response in expenditures will be less visible in the old group. These differences between the younger and older population are significant and persistent, lasting for at least 15 quarters. Wong explained that the higher consumption response of the younger population can be connected to the fact that the younger ones face a higher unemployment risk. Because they are scared, or they can more easily lose their job, their consumption response to a monetary policy shock will be much stronger. Therefore, population ageing can lead to a dampened aggregate consumption response to monetary policy. He found out that population ageing dampens the response of expenditure to a 1 percentage point to a contractionary monetary policy shock (Wong, 2014).

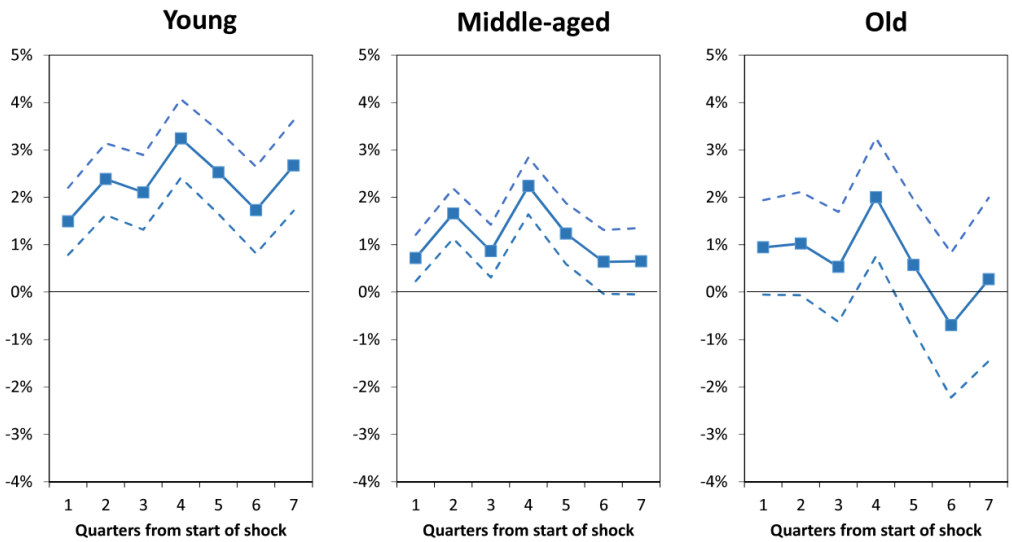
Wong (2014) also found out that households with lower levels of financial liquidity will reduce their consumption or expenditures more than the ones with high financial liquidity. These findings are consistent with many studies claiming, that younger households that, have lower financial liquidity will have a higher marginal propensity to consume, leading to more sensitivity to a monetary policy shock.

Another explanation for why the consumption response of the young population will be higher than the one from the older population is due to the fact that the young group has a higher propensity to adjust their loans. If there is a change in interest rate, the younger population will adjust their loans to this new interest rate, leading to larger changes in their consumption patterns. For example, if there is a decrease in the interest rate, the

young population will adjust their loans to this lower interest rate giving them more benefits they will use for higher consumption (they would have more money to consume). The older population, which is not that connected to loans, will react less, leading to smaller changes in their consumption patterns. If we compare two differently aged countries, Florida with and older and California with a younger population, it has been found that each 1 % rise in the old-to-young ratio will lead to a lower aggregate consumption response to monetary policy shock by 0.5% to 0.7%. Additionally, the consumption elasticity of young people is almost 2 to 3 times higher than the average person in the economy, leading to around 70% of the total aggregate consumption response. Consumption elasticity declines with age, leading to smaller consumption responses in older populations (Wong, 2015).

Decreased consumption response to an expansionary monetary policy shock in the ageing population is presented in Figure 2. In Figure 2, we can see that in the case of young agents, the consumption response to the presented monetary policy shock will be the highest, around 1.5% in the first quarter and almost 3% in the fourth quarter after the shock. On the other hand, consumption response will be much smaller among middle-aged and old agents. Looking at the response of old agents, we can see that in the first quarter after the shock, their consumption response will be around 1%, rising to 2% in the fourth quarter. In Figure 2, we can also see that after the fifth quarter, the consumption response of old agents to an expansionary monetary policy shock will decrease to negative values, while it will be positive in the group of young and middle-aged agents (Wong, 2015).

Figure 2: Consumption response to an expansionary monetary policy shock



Source: Wong (2015).

Berg, Curtic, Laugauer & Mark (2019) have made an analysis, where they check, what the response of consumption expenditures connected to different age groups will be to four different monetary policy shocks. They divide the population into three age groups and include them in the life-cycle model using structural vector auto-regression. Their results were quite surprising since they found out that the older part of the population will have the highest consumption response to monetary policy shock. The explanation for this lies in the fact that the older population tends to be wealthier than the middle and the younger ones. Because the older population finances its consumption mostly with savings and other financial assets, they are more sensitive to an interest rate change or so-called monetary policy shock. On the contrary, the younger population finances its consumption mostly through their labor income, meaning that their sensitivity to the interest rate will be much smaller than the one of the older population. If there is a decrease in interest rate, the older population will gain more from it leading to a higher consumption response. The older population can only change its consumption when a monetary policy shock occurs; on the other hand, the middle and younger one can change consumption and also the labor supply. Doing the Monte-Carlo experiment, they also found out that in the group of young population, those with lower income will have a higher consumption response to a monetary policy shock. Another reason why the consumption response of the older population is bigger is that older people discount the future more heavily on account of a higher life expectancy. If a monetary policy shock happens, the older ones will react strongly, mostly because they need to deploy their wealth across the remaining living years.

As we can see, the wealth of the population is a very important thing in this channel since it smooths consumption over the life cycle. Due to the higher wealth, individuals can change their saving, consumption, and investing behavior, which has an important role for the whole economy in the future. Many researchers from Canada and the United States of America have shown that there has been an increase in median wealth with age, meaning that wealth is increasing with age. The fact that the older population has larger wealth position, which can cause a big change in their consumption patterns. Following that population ageing and changes in the consumption behavior of the older generation might increase the value of the consumption channel (Howe, 2018; Lafrance & LaRochelle-Côté, 2012).

From the presented results, one could conclude that the aging population will have a negative impact on the consumption response. Although we can see that many researchers have already succeeded in proving that an ageing population could have a positive effect on consumption, we find much more evidence that confirms the negative effects of population ageing on consumption. The problem is that the population of countries varies greatly. The consumption response thus largely depends on the individual population and its age and wealth composition.

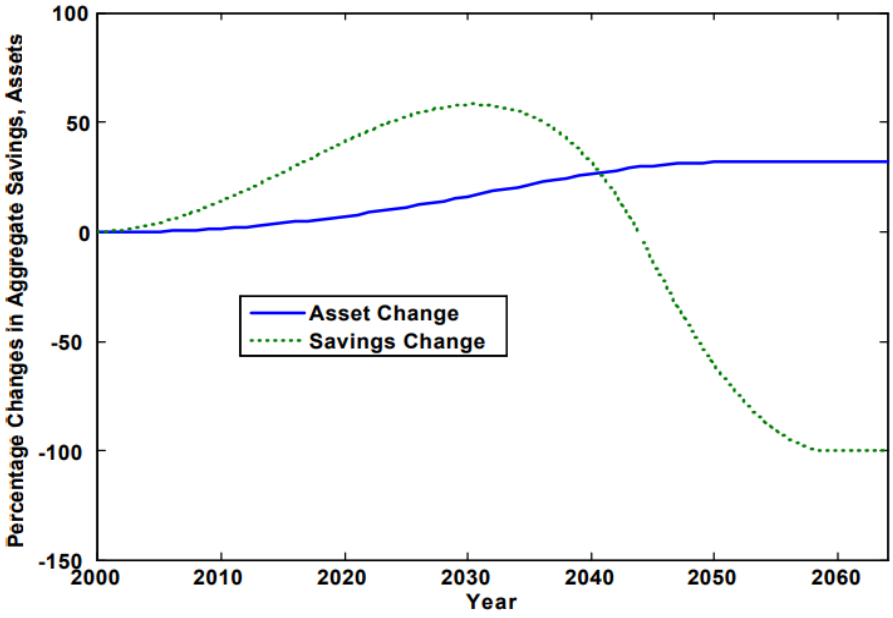
2.2 Savings Channel

The second field that can be affected by the ageing of the population is the field of saving and investment. The majority of the research done to determine the effects of population ageing on the economy is related to the study of the behavior changes of the older generation and the impact of these changes on the economy. It is well known that consumption habits vary greatly among different age groups. The most noticeable changes are, thus, visible mainly in the area of savings. While the working group saves much more than it spends, the older and the younger parts of the population are characterized by the exact opposite. The negative effect of ageing on savings occurs mainly due to a drop-in income once people retire. Due to the lower monthly income of older people, they save less money, while their consumption changes by a little. On the other hand, the working population is saving more, mostly for their longer retirement period, due to the longer life expectancy and, the reason that they have fewer children to take care of. Combining the negative effect of the older population and the positive effect on savings by the working population, we get an overall decrease in private savings due to the larger amount of elderly in the society (International Monetary Fund, n.d.).

According to the life-cycle theory, people in their late middle age, before retirement, are saving much more in order to support their consumption and living in a longer life period. Due to this increased saving, their wealth-to-income ratio will be the highest. Additionally, we can mention that due to the larger share of older people, pension provisions can be smaller, leading to the higher importance of private savings that, are more sensitive to interest rate changes. Because savings will increase mostly in the late middle population, which is risk-averse, reinforced price stability will be needed. Increased savings will be, therefore, mostly due to the purchase of non-risky and stable government bonds, supporting the statement that the older ones prefer a stable economic situation with no big risk included (European Central Bank, n.d.b).

Krueger (2004) incorporated the decrease in fertility rates and increase in longevity into the Modigliani and Brumberg life cycle model and showed that decreased savings by the older ones will have negative effects on per capita savings and a positive effect on per capita assets in the long run. His results are visible in Figure 3, where we can see the movement of the assets change and the savings change happening due to the ageing of the population. In the years between 2000 and 2040, the aggregate savings will increase together with the increase in assets. After that year, the effects of population ageing will start to be visible, leading to a decrease in savings and an additional increase in assets. He confirmed that the effects will be negligible in the short run and that after 60 years the economy will be pushed to the new equilibrium with lower per capita savings and higher per capita assets.

Figure 3: The effects of population ageing on savings and assets (per capita)



Source: Krueger (2004)

A negative correlation between the dependency ratio and the aggregate savings rate will, therefore, lead to a decrease in that savings rate. For every 1 percentage point increase in the elderly or young dependency ratio, the aggregate savings rate is projected to fall by around 0.61 to 0.86 percentage points. Additionally, the impact on interest and exchange rates will be visible due to these changes in the savings rate, which can further weaken the whole economy (Morrow & Roeger, n.d.).

2.3 The Wealth and Credit Channel

As we have learned so far, the ageing of the population can have major effects on the functioning of macroeconomic variables in the economy. In addition to the effects of population ageing, that are visible within the formation of consumption and saving habits, the effects of population aging can also be detected within the credit and wealth channels. In accordance with the changed wealth picture of the ageing population, some changes can also be detected in the field of crediting and private investments. Focusing on the credit channel, there will be more local deposits accompanied by higher savings rates. As said before, people are saving more of their income at their working age in order to finance their consumption in the future. If we again look at Figure 3, we can see that until the year 2040, the change in savings will be positive. This will happen due to the fact that the people or agents in their working years will start to save more and more money in order to enable a better life in their retirement period. Due to that, they will increase their saving rate during the working age. When they will enter retirement age, they will hold more money (saved money from their working ages), leading to increased local deposits

into the banking system. Banks will, therefore, experience a higher credit supply, which can cause an increase in certain prices. Banks of the older population can also relocate this higher credit supply to the countries with the younger population since the younger population can be understood as a population with big borrowing needs. Following this, the efficiency of the credit channel may increase due to the population ageing (Doerr and Kabaş, 2019). On the other hand, the credit channel will be connected to the interest rate channel. There is a positive connection between age and net worth and the amount of the so-called collateral. Higher net worth and collateral in the ageing population, will lead to cheaper borrowing since the finance premium will be smaller. Additionally, the risk premium will be much smaller in the older population than in the younger ones. The younger group is considered to be riskier than the older one. Another explanation can be done through the basic life-cycle hypothesis, saying that the younger population will borrow more compared to the middle-aged and older population. Since the number of loans and other borrowings will decrease with age, this will lead to less individual debt financing which will lower the importance of the credit channel. (Kronick & Ambler, 2018, page 5).

Fedotenkov (2015) did a study where he showed why population ageing might be a reason for the deflationary pressures in the economy. He explained it through the credit channel, saying that due to the lower fertility rate of the ageing population, there will be a smaller demand for credits, and a higher capital-to-labor ratio accompanied by lower money creation, which can lead to a decrease in prices. At the end of his analysis, he explained three main forces, that will lead to lower price levels. The first one is connected to the lower fertility rate and smaller demand for credits, the second one is saying that if the intertemporal elasticity of substitution will be smaller than the unity, due to the fewer and fewer children born, there will be lower consumption and higher savings, leading to positive effects on the supply of goods, which will cause a decrease in price levels. The last, third effect on prices is done through higher longevity, due to which savings of the individuals will increase, leading to deflation through the raise in the supply of goods.

The ageing of the population can have a big effect on the wealth channel as well. Ageing will lead to a smaller labor supply and a higher real wage, which can change the effectiveness of the wealth channel. Increased longevity together with lower fertility rates will lead to more capital and less labor in the economy, leading to lower rates of returns on capital and higher wages (Cima, 2022). Due to that, through the process of ageing of the population, the wealth channel will improve. Following the life-cycle hypothesis, it is known that young agents will be known as borrowers and old agents as lenders. Borrowed money of young agents from the old agents will be redistributed between investments in different assets, which will have a positive impact on wealth. Since net wealth will increase with age, the older population will become more sensitive to interest rate changes (Kronick & Ambler, 2018, page 6). However, Fujiwara & Teranichi (2006) showed that the monetary policy scheme does not need to be changed, if this problem of population

ageing is happening in a reasonable manner. Since workers prefer inflation-tightening monetary policy more than the retired due to their working manners, there exists a big tradeoff between the welfare of workers and the welfare of retirees. But in their analysis, they found out that if the population is ageing, this leads to a big change in the behavior of retirees since they start working more to support their consumption for longer longevity, which is somehow making this trade off less severe. Due to the smaller trade-off between the welfare of workers and retirees, monetary policy should be working with the inflation rule as a main policy instrument.

2.4 Interest Rate Channel

Until now, we saw that demographic trends may affect many politics in a certain economy. Increased life expectancy will motivate households to increase the rate at which they are accumulating assets. Additionally, the lower share of workers in the labor markets will make capital relatively abundant. Together, an increase in the interest rate of assets of households and redundant capital, and a decrease in the natural rate of interest will be noticeable (Bielecki, Brzoza-Brzezina & Kolasa, 2019).

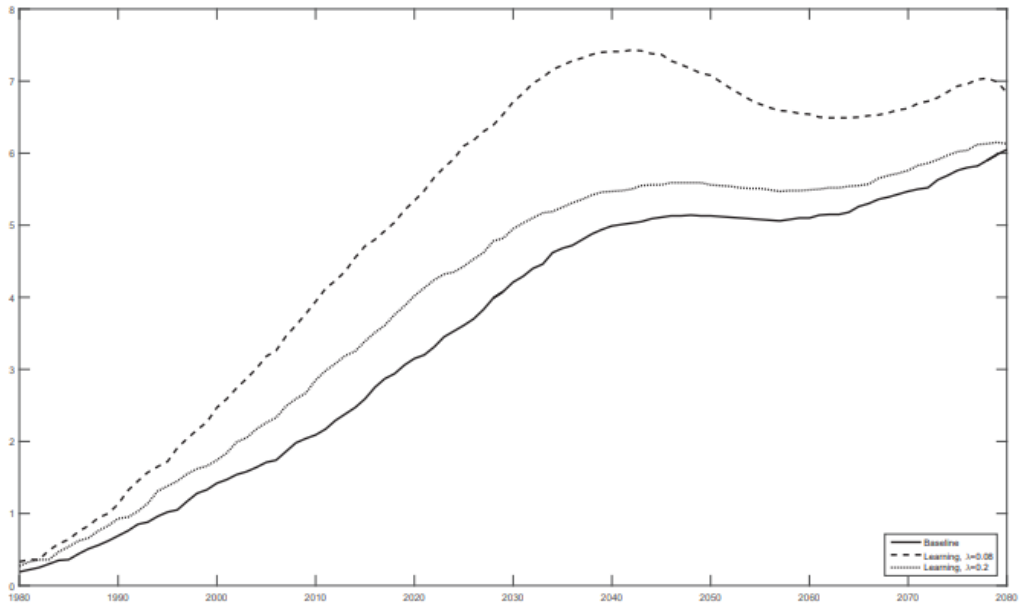
Ageing of the population can decrease the natural rate of interest, which is one of the main parameters of monetary policy used for the stabilization of the economy. Since older people prefer low and stable inflation, due to assets financing their consumption, they can put downward pressure on the natural rate of interest, causing a decrease in the average nominal interest rate. The decrease in a nominal interest rate will imply less space for a conventional monetary policy reaction to different economic shocks, leading to lost efficiency and credibility to stabilize the economy. Economists are emphasizing that if a monetary policy will not react quickly to these demographic changes happening, then the problem of persistent deflationary bias may occur. Including low and stable inflation, the problem of hitting the ZLB may also be the reason why demographic changes such as the population's ageing need to be considered in the field of monetary policy (Bielecki, Brzoza-Brzezina & Kolasa, 2018).

Using a simple New Keynesian model with overlapping generations and the real and nominal rigidities included, we can show that population ageing can have a sizable impact on the interest rate channel. Increasing the dependency ratio can decrease the real interest rate, by almost 1.5 percentage points in 50 years' time period. On the other hand, increasing life expectancy may be responsible for about 50 to 60 % of the decline in the natural rate of interest. However, the situation related to the effects of population ageing on the interest rate channel is not entirely pessimistic. If the central bank reacts to the reduction in the natural interest rate by adjusting the policy rate, the effects of an ageing population can be largely offset. But another big problem can arise in the case of ZLB. When monetary policy strikes at, or is already on the ZLB, a reaction by lowering the monetary policy rate is no longer possible, which means that monetary policy thus loses

all its power in combating the negative effects of an ageing population. In case the country finds itself in the trap of the ZLB, monetary policy does not have the power to change its political measures, which can lead to very low and stable inflation due to a sharp reduction in the natural interest rate (Bielecki, Brzoza-Brzezina & Kolasa, 2018).

In Figure 4, we can see the results from the research, where the authors compared the effects of learning monetary policy on the phenomenon of downward pressures of population ageing on the natural rate of interest. In the baseline scenario, they assume that the central bank knows the natural rate of interest and the value of the potential output. In two other scenarios, the central bank will not know for sure the value of the natural rate of interest and potential output, but it will be able to learn about them at different speeds of learning. In the second scenario, the speed of learning will be 0.08 and in the third, it will be higher at 0.2. In Figure 4, we can see that learning about these two variables will lead to a higher risk of hitting the ZLB, mostly due to the imperfect knowledge of presented variables in times of low inflation and depressed nominal interest rates. The analysis also established that slow learning of a monetary policy about the variables, can lead to overestimation of the natural rate of interest and potential output, which consequently leads to a higher risk of ZLB and liquidity traps. On the other hand, in the case of rapid learning, the level of hitting the ZLB was smaller than in the case of slower learning, but bigger than in the baseline scenario. In the case of rapid learning of monetary policy about the natural rate of interest and potential output, ZLB would amount to around 4% in 2030, while in the case of slow learning the risk level of hitting the ZLB would be between 4-6% by 2020. We can see that due to the population ageing monetary policy must change its way of working to minimize the effects of population ageing on the economy. A change in the monetary policy response, i.e., more aggressive monetary policy can reduce the possibility of hitting the ZLB and, reduce the risk of deflationary bias. Due to the more aggressive response of hawkish monetary policy and quicker learning, a decrease in the volatility of the nominal interest rate will be visible (Bielecki, Brzoza-Brzezina & Kolasa, 2018).

Figure 4: Probability of hitting the ZLB



Source: Bielecki, Brzoza-Brzezina & Kolasa (2018).

The demographic transition from a younger to an older population will also decrease the real interest rate. This happens mostly due to the preference shock, which hit the households. Because longer life expectancy is considered, retirees and workers close to retirement will increase their savings, leading to a decrease in the real interest rate. Including social security into the model shows that even if we try to increase the social transfers given to retired people to decrease their savings, the reduction of real interest rate would still happen. Movement of the real interest rate in the case of population ageing together with higher social transfers will happen on three important levels. First, the real interest rate will remain almost flat in the first few years of population ageing. After a few years a big drop-in real interest rate will happen, leading to a slow adjustment of it at around -1% after some years. Even if the government tries to eliminate the effects of population ageing on the real interest rate, this cannot be achieved by increasing social security. Some policy changes will be needed, namely a greater emphasis on growing the GDP rate, through more investments and more savings, to fight against these negative effects of population ageing (Carvalho, Ferrero & Nechio, 2016, pages 1-20).

Evidence about the effects of population ageing, can also be shown with the affine term structure models, where the short-term rate follows the stationary vector autoregression process. The relationship between the ratio of middle-aged to younger ones (called MY ratio) and the real returns of bonds will be our main focus. When the MY ratio will be small the excess demand for consumption will arise mostly from a larger cohort of the younger population. In such cases in order to clear the market, equilibrium prices of financial assets would decrease, encouraging savings by the middle-aged population. It

has been shown that there is a positive correlation between real asset prices and the so-called MY ratio. Together with all the above, the authors also found out that the correlation between the MY ratio and the yields will be negative (Favero, Gozluklu & Yang, 2016).

The important implication of population ageing and the interest rate was also proven by Vlieghe (2016). He showed that the population ageing together with high public debt will lead to lower interest rates in such an economy. We can see that another variable may be important when speaking about the effects of population ageing on the interest rate channel. Countries with a lower rate of public debt can, therefore, expect a lower decrease in the interest rate, saying that the effects of population ageing in a country with a low public debt will be smaller.

In all the presented cases, we can see that population ageing will reduce the interest rate channel effectiveness of the monetary policy. Above all, the problem of hitting the ZLB will be higher, meaning a big limitation of monetary policy functionality. Since the interest rate channel of monetary policy will lose its power due to the population ageing, more active and changed monetary policies will be needed in order to eliminate the negative effects of demographic changes on the economy (Mäki-Fränti, Kliponen & Kinnunen, 2015).

2.5 Inflation Channel

Many economists have been researching the connection between the inflation rate and the age structure of the population for many years. The inflation puzzle, which arouses the interest of many researchers, represents one of the main topics within the field of monetary policy. In 1955 and 1975, when inflation in the United States was very high, the questions about what drives this inflation rate up formed. The number one explanation for such large inflation was connected to the inflation expectations of the consumers. Since their expectations of inflation rose, the inflation remained high, while output did not change much. After some years, inflation fell back to around 1%, which was again explained by lowered inflation expectations of the consumers. But, in 2008, the financial crisis happened, leading to a reduction in inflation rate, which did not pick up after the recovery of the economy. Stable and low inflation in these recovered countries, thus, represented a major milestone in the research of what can affect and drive inflation. One of the variables that could play a big role in the movement of the inflation rate is demography (Juselius & Takáts, 2016).

There exists a clear connection between inflation and the age structure of the population, which can be explained through saving behavior. Smaller savings by older agents will negatively impact the inflation rate in the economy. Following these logical statements, we can agree that demographic projections of a certain economy could be put to good use in the field of inflation forecasting. Projections of the changing age structure could,

therefore, play an important role in the conducting of monetary policy in the future (Lindh & Talmberg, 2000).

Albuquerque, Caiado & Pereira (2020) found out that there exist two main arguments that explain the connection between population ageing or demography and inflation. The first one is economic, saying that excess demand drives inflation up, while excess supply leads to a decrease in inflation. Following that statement, we can say that when the share of young and old people in the population will be large, we can expect an increase in the inflation rate since young and old people consume more than they produce, leading to excess demand in the economy. If the demand will not exceed the supply, even if we have a large share of a young or older population, we will get a negative impact on inflation, leading to a decrease in inflation rates. We can see that both explanations, whether population ageing is inflationary or disinflationary, are correct, it is just a matter of explanation which motive will prevail, the excess demand one or the excess supply one. The second argument is political, saying that older people prefer stable and low inflation, which protects the value of the assets they used to finance their consumption and living. Since in an ageing economy, the share of older people will be higher, this will lead to a decrease in inflation, meaning that the government will be forced to choose more tax-financed public debt together with low and stable inflation.

As in other channels, population ageing effects will happen due to the changed behavior in the economy. Since then, we have learned that in large cases, the population is divided into three age groups, which differ mostly in consumption and savings patterns. Excess demand among the young and old agents will lead to an increase in the inflation rate, while in the middle-aged group, these effects will be negative due to excess production. However, the opposite pattern may happen among the old agents, since they will increase their savings to finance their future consumption. Due to that, we can find in many researchers' works that savings will increase in the last few years of the working period and at the beginning of the retirement period. When the government increases the retirement age threshold and when the social transfers to retired people increase, we can expect that the aggregate savings will also increase leading to lower consumption of the old group. Smaller consumption will, therefore, result in lower inflation. Following this new pattern of increased savings and lowered consumption in the older part of the population, it is leading to the result, that population ageing can also put disinflationary pressures on the economy (Albuquerque, Caiado & Pereira, 2020). Additionally, there exist two other explanations that explain why population ageing can put negative pressures on the inflation rate. One is due to the fact that population ageing will decrease the labor force, leading to a fall in consumption and investments. A fall in the supply side of labor will lead to higher real wages leading to a reduction in labor demand. Another one is the decline in saving rate because the older generations will save less due to lower monthly income (Rehn, 2021; Andreson, Botman & Hunt, 2014, pp. 12-17).

The effects of population ageing on the inflation rate can be explained in many ways. Juselius & Takáts (2005) found a stable and significant correlation between demography and low-frequency inflation in their study of 22 advanced economies between 1955 and 2010. They found that demography is responsible for about 30% of the whole inflation variation between 1970 and 1990. In their study, they found out that there is a simple U-shape pattern, meaning that the inflation will be high in the younger and older population and, smaller for the middle-aged part of the population. Following this, a positive correlation between the inflation and the dependency ratio exists, but we need to consider that there is a big heterogeneity across countries. The only problem they spoke about is the smaller robustness of the data for the very young and the very old group, that may not follow this presented U-shaped pattern. Albuquerque, Caiado & Pereira (2020) also conclude that a positive relationship between population ageing and the inflation rate exists. Their argument, why the ageing of the population will have a positive effect on the inflation rate, was based on the fact that the ageing of the population will lead to a lower supply of labor, which will have a positive effect on the real wage and an increase in inflation. Since excess demand is also associated with the older generation, additional inflationary pressures will be contributed.

Population ageing will reduce the supply of the labor force, leading to a reduction in the potential output growth. The effects of population ageing will, therefore, depend on the adjustment of the aggregate demand to this new aggregate supply. If the aggregate demand will adjust quickly enough, then we could expect little or no effects of population ageing on the inflation rate. The problem that may arise when we start speaking about population ageing and inflation is that the ageing can also affect other variables that can then indirectly affect the inflation rate. One of these variables is the price of land, which will decrease when the population ages. This can be supported by the explanation that the consumption habits of the elderly are different from the rest of the population. Elderly people spend less money on land and at the same time prefer to live in smaller houses and on smaller land. A decrease in the price of land can, thus, further reduce the inflation rate, even if aggregate demand and aggregate supply adjust quickly enough. Another variable that can be affected by population ageing is the fiscal position of the country. The ageing of the population causes an increase in fiscal costs intended for the payment of pensions and other expenses, which in turn worsens the debt position of the individual country. Together with that, additional fiscal consolidation, due to an increase in fiscal expenditures, can thus lead to a long period when the real GDP will be below the potential one, which in turn has a negative effect on the inflation rate. Both of these variables decreased in Japan, which has one of the oldest populations in the world. Results from the Japan case are, therefore, saying that population ageing will most negatively affect the inflation rate, leading to low and stable inflation, which can cause many problems, especially in the field of monetary policy and its inflation targeting (Anderson, Botman & Hunt, 2014). Bean (2004) claims that additional disinflationary pressures on population ageing can happen since the elderly prefer more stable and less risky assets. They will

most likely invest in risk-free bonds and less in risky equity assets, there will be a higher average wealth leading to lower inflation for a longer period.

We can see that there are multiple ways through which population ageing can affect inflation. The effects of population ageing on inflation, therefore, depend on fact, which one of these will prevail. A lot of work is needed in order to get definitive conclusions about the actual effects of population ageing on the inflation rate. Since the size and the effects of population ageing in each country differ greatly, depending on the prevalence of different motives for ageing, it is, therefore, very difficult to estimate some kind of "stable" effects that would be present in all countries. If we want to know which effects will happen due to population ageing, we need to look at each economy closely, finding out which channel of influence will be the dominant one (Albuquerque, Caiado & Pereira, 2020). Katagiri, Konshi & Ueda (2013, pp. 13-14) found, that the effects of population ageing on inflation will depend on population ageing causes. In their opinion, if population ageing will happen due to increased longevity, then we can expect the deflationary pressures of ageing in the economy. If population ageing will be followed by a decline in the birth rate, then the effects of population ageing will be inflationary.

2.6 Population Ageing and Monetary Policy

The effects of population aging are already causing some problems in many countries. Demographic changes, such as population ageing, are known as macroeconomic shock that will lead to quick movements in asset prices and savings. These movements will affect the natural rate of interest and the natural rate of unemployment. Additionally, demographic changes can also change the wealth channel and its importance, which will furthermore lead to a flatter Phillips curve due to the bigger share of retired people and smaller labor supply (Baksa & Munkacsi, 2019). The problems associated with the ageing of the population are mostly visible in the fiscal area, where they cause many problems related to the financial stability of the country and its debt position. Accordingly, the ageing of the population can also have strong effects on monetary policy. Due to the assumptions of the life cycle hypothesis, where the young are recognized as borrowers and the elderly as creditors, the ageing of the population can affect the formation and movement of the interest rates, which are considered to be one of the key instruments of every central bank. Changes in the fields of interest rates, inflation, wealth, and others can thus strongly influence the operation and the response of the monetary policy, and can additionally worsen its effectiveness, in the case of inappropriately designed monetary policy (Mester, 2018). The overall effects of the population ageing problem on monetary policy are shown in Table 1. We can see that the effects of population ageing on monetary policy are happening through five channels, mostly causing negative effects on monetary policy and its efficiency.

Table 1: Overall effects of population ageing on monetary policy

CHANNEL	POPULATION AGEING EFFECTS
Consumption channel	- A smaller consumption response to the monetary policy shock due to the higher household margin and lower unemployment risk of old people. - A smaller expenditure response to the monetary policy shock since old people change their expenditures only by a little. - A smaller consumption sensitivity to monetary policy shock due to the higher financial liquidity of old people. - A smaller consumption response due to a smaller propensity to adjust the loans to the new interest rate and due to the lower consumption elasticity of old people. Old people rent less credit, which leads to a smaller adjusting propensity of loans. - A higher consumption response due to bigger wealth and higher discounts on account of the higher life expectancy of old people.
Savings channel	- A smaller saving response to the monetary policy shock due to the lower monthly income of old people. Old people get lower monthly incomes, leading to a decrease in savings and savings rates. - A lower savings rate due to the higher dependency ratio, leading to a weakening of the monetary policy and the whole economy.
Credit channel	- A higher credit channel efficiency due to the higher deposits from old people to the banking system. Due to the higher savings from their working ages, they have more money when they enter retirement. This money is then transferred to the banks in the form of deposits. - Negative effects of the population ageing on inflation through the credit channel due to a lower fertility rate in the old population which, will lower the demand for credits, leading to a decrease in prices. Due to the smaller intertemporal elasticity of substitution of the older population, there will be smaller consumption and higher savings leading to a decrease in the price level. Higher longevity will increase savings in the working period leading to an increased supply of goods and a decrease in prices. - A smaller importance of credit channel due to the smaller amount of credit and less individual debt financing of old people. In their retirement period they start using their saved money to finance their consumption and living, which leads to a smaller amount of savings and fewer deposits.

(table continues)

Table 1: Overall effects of population ageing on monetary policy (continued)

CHANNEL	POPULATION AGEING EFFECTS
Wealth channel	- A higher wealth channel importance due to the increased wealth in the older population. Improved wealth channel due to the lower rates of returns on capital and higher wages in the old population. - A higher importance of inflation rule as a main policy instrument of monetary policy due to the smaller trade-off between the welfare of workers and the welfare of retirees. People will work longer in order to save more money for their retirement, leading to smaller differences in welfare between workers and retirees.
Interest rate channel	- Since old people prefer low and stable inflation due to the more assets financing their consumption, downward pressures on the natural rate of interest and nominal interest rate may occur, leading to lost efficiency of monetary policy. - Negative effects of the population ageing on the zero lower bound problem, due to the decrease in the nominal and natural rate of interest, leading to lost power and influence of monetary policy. - A decrease in the real interest rate due to the preference shock in the older population. People close to retirement start working and saving more, putting downward pressure on the real interest rate. - A problem of the public debt in the old population, where higher public debt will lead to a higher decrease in interest rate. The old population with higher public debt will, therefore, suffer from a higher decrease in the interest rate than the old population with lower public debt.
Inflation channel	- Since average savings will be smaller in the older population, negative effects on the inflation rate will happen. Old people will save less in their retirement, leading to deflationary pressures. - Population ageing can cause the excess demand problem, leading to a higher inflation rate. There exists a positive correlation between the dependency ratio and the inflation rate. - A higher share of old people in the population will lead to higher demand and lower supply, which will put upward pressure on the inflation rate.

(table continues)

Table 1: Overall effects of population ageing on monetary policy (continued)

CHANNEL	POPULATION AGEING EFFECTS
Inflation channel	- Changed preferences of the old people about inflation will decrease the inflation rate. Old people prefer low and stable inflation that will protect the value of their assets. - Smaller consumption of the old people will result in lower inflation rate in the economy. - Population ageing will lower the labor force, leading to smaller consumption and investments in the economy. On the other hand, real wages will increase, followed by a decrease in labor demand, leading to an overall decrease in the inflation rate. - Population ageing can also lower the price of land, leading to additional deflationary pressures in the economy. In the old population there will be a smaller demand for buying land, leading to a decrease in land prices, that will further more negatively affect the inflation rate. - Due to population ageing, the fiscal position of a country will worsen, leading to deflationary pressures in the economy. Increased fiscal costs will lead to higher debt in the old population, leading to additional deflationary pressures in the economy. - Lower inflation in the older population will also happen due to the changed motives of investing. Old people will invest more in risk-free assets, leading to higher wealth and lower inflation in the economy.

Source: Own work.

In Table 1, we can see that population ageing can lead to a decrease in the natural rate of interest, which will make monetary policy overly restrictive, furthermore leading to a deflationary bias and different trends in the potential output growth. The best response for monetary policy that is dealing with population ageing is to care the same about output growth and inflation. If the central bank will treat inflation and output growth in the same way, then even in the case of slower learning we can expect lower deflationary bias (Bielecki, Brzoza-Brzezina & Kolasa, 2018). Another argument as to what monetary policy can do in order to fight these negative effects of population ageing is pointed to the fact, that population ageing will lead to lower full-employment real interest rate, which needs to be increased. A reduction in the full-employment real interest rate will, therefore, lead to great secular stagnation pressures, which can be understood as a nightmare for a monetary policy. To prevent such chaotic situation, monetary policy should reduce the real interest rate and start to consider operating with the higher inflation

target rate so that the nominal interest rate will correspond to the lowered real interest rates. Another response can be through the increase in demand, done by promoting more investments and reducing savings (Summers, 2014).

The effects of population ageing on the monetary policy were also investigated by Bielecki, Brzoza-Brzezina & Kolasa (2018), where they determined whether monetary policy learning, about the changing structure of the population, can help with the reduction of the negative effects of the presented demographic problem. With the help of the New Keynesian model with overlapping generations, they tried to find out, how the level of learning of monetary policy, about the ageing of the population affects the reduction or the increase of the impacts of the selected shock. They found that in the case of slower learning of monetary policy about demographic changes, there is an overestimation of the natural interest rate. They also found that in the case of slower learning, the real effects of population ageing are fairly small. As a matter of great interest, they pointed out that in the case of poor learning of the monetary policy, the problem of going away from the inflation target can happen, meaning that the monetary policy can no longer stabilize inflationary pressures in the economy. In the case of slower learning, such nominal variables are strongly affected by the effects of population ageing, which can lead to a large deflationary pressure on which monetary policy can no longer influence with its full power. In the case of faster learning, the misperception about the natural interest rate and the disinflation pressures will be smaller, but still non-negligible. The same results were found by Galí (2016). He used the learning against the bubble (hereinafter: LAB) technique to show that the learning against the bubbles in the interest rate may help succeed in insulating inflation and output from its aggregate bubble fluctuations and keep them more stable. In addition, he managed to prove the fact that in the event that LAB will not successfully remove the fluctuations within inflation and output, it will only cause an increase in the volatility of consumption variables. He concluded that even the monetary policy, which focuses on output targeting and somehow ignores the bubbles, can also succeed in stabilizing macroeconomic indicators.

2.6.1 Monetary Policy Efficiency

Since population ageing will affect monetary policy through different channels, i.e., interest rate channel, wealth channel, and others, the effectiveness of monetary policy can be put in question. Following the basic life-cycle hypothesis, i.e., households will borrow in their young years, accumulate, and pay off loans in their working years and use payouts from the owned assets when they retire. In the scientific world, we can find many articles that have been written on this very topic, related to changes in saving and consumption throughout the life cycle. Many thinks that the change, especially in saving, may lead to a worsening of monetary policy, as the older population is considered to be less responsive to shocks (Imam, 2014, pages 1-2).

Imam (2014) claims that an ageing society may worsen or increase monetary policy efficiency through different channels. Through the interest rate channel, the efficiency of monetary policy will be worsened, due to the lower interest rate sensitivity of the older population. Since older people sell their assets when they enter retirement to finance their consumption, they no longer react to changes in interest rates done by monetary policy. The same is happening in the case of a credit channel that becomes less risky since older people prefer stable and risk-free financial instruments. Due to the risk aversion of the older population, monetary policy loses its influence by changing risk premiums or other financial instruments. For monetary policy, also the expectation channel may be important. Many say that this channel will not be influenced so much by the ageing of the population, but there is some knowledge that inflation expectations may rise with age. A rise in inflation expectations will happen, mostly due to the more risk-averse older people, who will care more about their wealth, since they only have this one source of income to finance their consumption. Through this, we come to the next, a wealth channel, which may increase monetary policy efficiency because the older population will care more about their wealth, meaning that they will react more to monetary policy shocks in the economy. As an interesting point, it is worth noting, that the ageing of the population can also have some effects on price development. Due to the change in the age structure of the population, there may be a drop in the aggregate demand, which will cause negative effects on the price situation, if the aggregate supply will not react immediately to the changes in the aggregate demand. In case of non-reaction or later reaction of aggregate supply, we can, therefore, expect deflationary pressures, which will greatly affect the strength and effectiveness of the monetary policy. Doing the basic Bayesian vector autoregression, Imam found out that the ageing of the population will worsen the impact of monetary policy on inflation and unemployment by 0.1 to 0.35 percentage points.

As said before, the ageing of the population will lead to a decrease in the natural rate of interest, due to the higher share of older people, who will save less. A reduction in the natural rate of interest will happen also due to the decreased labor supply because a big share of the older people will retire and leave the labor market. All this can furthermore lead to a lower monetary policy efficiency on the output gap due to the decreased interest rate sensitivity of the society as the population ages. Following that, the trade-off between output and inflation will decrease, leading to big problems connected to the operation of the monetary policy (Kantur, 2013).

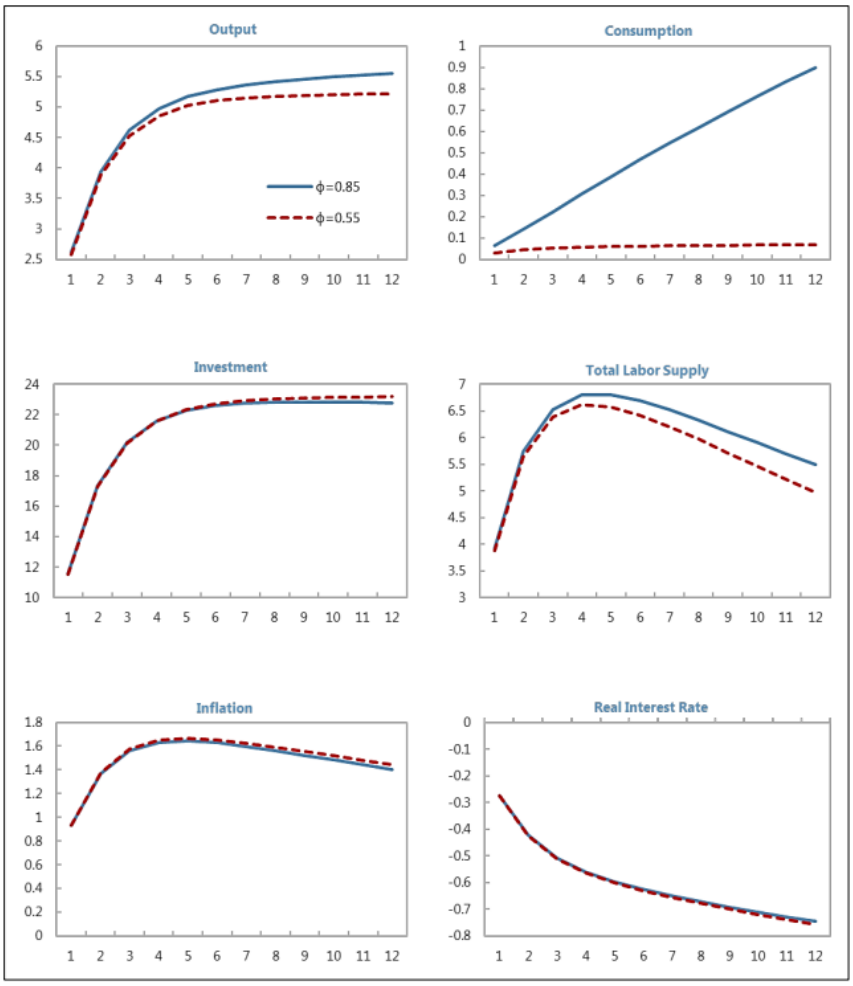
Kantur (2013) argued that the effectiveness of the monetary policy on the output gap will decrease with ageing, because in the case of a big and positive dependency ratio, tightening monetary policy shock will lead to a decrease in consumption of the young and an increase in the older consumption. An increase in older consumption will happen because older people use previous period information about their consumption and are somehow reacting with a one-period lag. The younger ones will reduce their consumption and increase their savings if a tightening monetary shock will happen. Due to the increase

in interest rate, bigger savings of the older generation will lead to higher wealth, allowing bigger consumption of the older part of the population. Said differently, since this older part of the population was one time the younger one and they increased savings back then, they will not suffer from the higher wealth due to the increased interest rates. They will sell some of their wealth to the younger population, which will allow them to spend and consume more. On the other hand, tightening monetary policy shock will lead to a decrease in total output since the decreased demand of the younger part of the population will be higher than the increased demand of the older ones.

Kronick & Ambler (2018) argued that inflation targeting may be playing an important role in monetary effectiveness in the ageing of the population. Since inflation targeting may leave less room for the central bank channel in interest rates, the problem of ZLB may be implemented. Since population ageing will lead to lower interest rates, the central bank will be forced to reduce its rate, which can be quickly obstructed due to the ZLB problem. For their analysis of Canada's monetary policy effectiveness in the ageing population, they found out that the efficiency will be decreased mostly due to the negative credit channel.

The negative effects of population ageing on monetary policy efficiency have also been proved in the paper by Ahn & Blomhoff (2019), in which they claim that from 1970 to 2015, monetary policy transmission channels became weaker, mostly due to demographic changes. They also added that the number one reason why the negative effects of population ageing on monetary policy efficiency are happening, is due to the increasing life expectancy. Following their results, we can expect even bigger negative effects of the population ageing on the monetary policy efficiency, since life expectancy is rising over the years. They expect that the monetary policy transmission channel in 2100 will be 75% less effective than in the 1970s. The same results were also given by Yoshino & Miyamoto (2019), that confirmed that the ageing of the population will negatively affect the monetary policy and its efficiency. They used the New Keynesian model with two types of households and nominal price rigidities included. Looking at Figure 5, we can see that the monetary policy effectiveness will be weakened in the ageing economy, especially in the field of consumption. Population ageing will lead to a weakened impact of monetary policy shock on consumption, accompanied by a weakened impact on investments and others macroeconomic variables.

Figure 5: The effects of an expansionary monetary policy shock



Source: Yoshino & Miyamoto (2019).

Leahy & Thapar (2019) found that the degree of the effectiveness of the monetary policy is largely related to the production sector and entrepreneurship or business. Since production and entrepreneurship are the largest, especially in the middle age group, as a result this group is also considered to lead to a more effective monetary policy. Due to the decline of entrepreneurship and production in an aging population, the effectiveness of the monetary policy will decline. In their analysis, they did the panel regression, which showed that the ageing of the population will not have a significant effect on the monetary policy efficiency. This will happen due to various channels, some of which will have a positive effect on the effectiveness of the monetary policy, and some of which will have a negative effect.

As said before, there are no exact effects of population ageing on monetary policy efficiency. It again depends on the fact which of these channels is the dominant one. If there is a strong wealth channel in the ageing economy, then we can expect bigger monetary policy efficiency. This is also the only channel, which will allow such positive effects of population ageing on the economy. All the other channels will, therefore, lead

to lowered monetary policy efficiency, due to the reduction in the sensitivity rates and others (Mäki-Fränti, Kliponen & Kinnunen, 2015). Following that, we can expect the negative effects of the population ageing in the monetary policy, but if this wealth channel will be strong enough, the effects can quickly turn in the opposite direction.

3 DYNAMIC NEW KEYNESIAN MODEL WITH OVERLAPPING GENERATIONS

In this chapter, I am going to use the model, developed by Kantur (2016). In his analysis, he used a two-period DNK model with overlapping generations. The model observes agents (workers and retirees) throughout their entire life and models the changes associated with the transition from one generation to another. The entire population is divided into two groups, that are born at different dates but have a finite lifetime. At the time of birth, agents became workers. At their working ages, they earn the wage by supplying labor and decide how much of it they are going to spend on consumption and how much they are going to save. The income of workers can be saved in two types of assets, one-period riskless bonds and equity shares of firms in the economy. In the second lifetime period, agents retire, meaning that they are not supplying the labor anymore and that they are no longer getting their wages as a source of income. In the end, before they die, they consume all their wealth. For the equity market, we have to mention that agents normally buy shares or bonds in the first period of life, to become the owner of them in the next period, when they will retire. On the supply side of the economy, there are also two types of firms, which produce two differentiated goods. The central bank and its monetary policy are following the basic Taylor rule from 1993, reacting to the output gap and inflation deviations.

3.1 Demographics

The total population of the economy (N_t) is divided into two different cohorts. The total population of time *t* is calculated as a sum of two cohorts, workers (${N_t}^w$) and retires (${N_t}^r$),

$$N_t = {N_{t-1}}^w + (1+n){N_{t-1}}^w . \quad (1)$$

Where n represents the fertility rate of workers, so that it holds ${N_t}^w = (1+n){N_{t-1}}^w$. It also holds, that the number of workers born in the previous time period is equal to the number of retirees in the next period (${N_t}^r = {N_{t-1}}^w$).

To analyze the effects of population ageing, the indicator of ageing is defined as the old-age dependency ratio (φ), which is calculated as a ratio between the retirees and workers in the economy,

$$\frac{{N_t}^r}{{N_t}^w} = \frac{{N_{t-1}}^w}{(1+n){N_{t-1}}^w} = \frac{1}{(1+n)} = \varphi \,. \tag{2}$$

We can see that the old-age dependency ratio is decreasing if the fertility rate (n) of the population is increasing when the population is growing.

3.2 Households

Following the model by Kantur (2016), we have two types of agents, both maximizing their utility functions subject to different budget constraints.

3.2.1 Retires

As mentioned before, each retiree (j) will consume all his wealth before death, leaving nothing behind. Below we can see the budget constraint function of retirees, which equals their expenses to their income

$$D_{t+1}(j)P_{t+1} = {B_t}^n(j)(1+i_t) + \int_0^1 \left(Div_{t+1}(i) + Q_{t+1}(i)\right) S_t(i,j)di \,. \tag{3}$$

$D_{t+1}(j)$ represents the consumption of the retiree, where P_{t+1} stands for the price of a good, both in the time *t+1*. Since our model include the equity market, we have a bit different right-hand side of our equation. ${B_t}^n(j)$ denote the nominal bond holding of agent *j*, which changes due to the nominal interest rate in the economy (i_t). An additional source of income represents the dividends (Div_{t+1}) paid from the final good firm (i). Lastly, $Q_{t+1}(i)$ denotes the price of share of each firm (i), and $S_t(i,j)$ shows the agent held number of shares of firm (i).

3.2.2 Workers

As said before, workers will supply labor and will be getting labor income as one of the sources of their income. They will start working as soon as they are born since the model considers this simplicity that we are born workers and we live for only two periods. Workers will also have the chance to buy different assets, bonds, or shares.

All workers will maximize their objective function,

$${V_t}^j = \frac{C_t(j)^{1-\sigma}}{1-\sigma} - \frac{L_t(j)^{1+\Psi}}{1+\Psi} + \beta E_t\left(\frac{D_{t+1}(j)^{1-\sigma}}{1-\sigma}\right) \tag{4}$$

subject to their budget constraints,

$$P_t C_t(j) + {B_t}^n(j) + \int_0^1 \left(Q_t(i) S_t(i,j)\right) di = W_t L_t(j) \tag{5}$$

$$D_{t+1}(j) P_{t+1} = {B_t}^n(j)(1 + i_t) + \int_0^1 \left(Div_{t+1}(i) + Q_{t+1}(i)\right) S_t(i,j) di \,. \tag{6}$$

$C_t(j)$ and $L_t(j)$, represent the consumption and the labor supply of a certain worker (j). The nominal wage rate of labor is denoted as W_t. In the equations, intertemporal elasticity of substitution (σ) and elasticity of labor supply (Ψ) are also included. By taking the first order conditions to this maximization problem, I got the next set of equations,

$$C_t(j)^{-\sigma} = \beta E_t \left(D_{t+1}(j)^{-\sigma} \frac{P_t}{P_{t+1}} \left(\frac{Div_{t+1}(i) + Q_{t+1}(i)}{Q_t(i)} \right) \right) \tag{7}$$

$$C_t(j)^{-\sigma} \frac{W_t}{P_t} = L_t(j)^{\Psi} \tag{8}$$

$$C_t(j)^{-\sigma} = \beta E_t \left(D_{t+1}(j)^{-\sigma} \frac{P_t}{P_{t+1}} (1 + i_t) \right). \tag{9}$$

From equation (9), the stochastic discount factor can be calculated as,

$$\Lambda_{t,t+1} = \frac{1}{1 + i_t} = \beta E_t \left(\frac{D_{t+1}(j)^{-\sigma}}{C_t(j)^{-\sigma}} \frac{P_t}{P_{t+1}} \right). \tag{10}$$

Furthermore, no arbitrage condition can be calculated from the first order conditions (hereinafter: FOC), equations (7) and (9),

$$E_t \left[\left(\frac{D_{t+1}}{C_t(j)} \right)^{-\sigma} \frac{P_t}{P_{t+1}} \left((1 + i_t) - \left(\frac{Div_{t+1}(i) + Q_{t+1}(i)}{Q_t(i)} \right) \right) \right] = 0 \tag{11}$$

which means it does not matter in which way workers save, since both bonds and shares will yield the same return in riskless economy.

3.3 Firms

In the whole economy, there are two types of firms. One is called final good firms which produce only the final good items, while the other is called intermediate good firm which supply only intermediate good. In the market of final good firms, a perfect competition

exists, while in the second market, where we can find the intermediate good firms, imperfect competition with a la Calvo pricing is considered.

3.3.1 Final Good Firms

Final good producers will take intermediate goods and transform them into the final goods ready for consumption. Their market will contain perfect competition among all firms on the market. Production function of the final good firm is, therefore, calculated as

$$Y_t = \left(\int_0^1 Y_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{12}$$

where, i stands for intermediate good ($i \in [0,1]$) and $Y_t(i)$ represents the quantity of intermediate good i. Price elasticity of demand is denoted by ε, $\varepsilon > 1$. The demand function for intermediate good i

$$Y_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} Y_t \tag{13}$$

will be calculated as the product of the ratio, between the price of good i ($P_t(i)$) and average price live (P_t), and the final good. The average price level, P_t, will be calculated as

$$P_t = \int_0^1 (P_t(i)^{1-\varepsilon} di)^{\frac{1}{1-\varepsilon}} . \tag{14}$$

3.3.2 Intermediate Good Firms

Intermediate good sector will contain continuum of firms indexed by $i \in [0,1]$, where each of them will produce the intermediate good, following the next production function,

$$Y_t(i) = N_t(i) \tag{15}$$

where $N_t(i)$ will denote the labor input. Labor market is competitive, meaning that the nominal wage rate (W_t) is taken as given.

Intermediate goods firms are owned by retired agents, who wants to maximize their wealth, as their only source of income. Demand function for the intermediate good will be a downward slopping curve and nominal profits (dividends) of the intermediate good firm will be calculated as

$$P_t Div_t(i) = P_t(i) Y_t(i) - W_t N_t(i) . \tag{16}$$

Optimal price (P_t^*), which will observe the shock in it, will be calculated as a product of marginal costs (MC_t) and the mark-up (μ).

$$P_t^* = \frac{\epsilon}{\epsilon - 1}\frac{W_t}{P_t}P_t = \mu MC_t \,. \tag{17}$$

In the symmetric equilibrium it will hold $P_t^* = P_t$ and $\frac{W_t}{P_t} = \frac{1}{\mu}$. As mentioned before, intermediate good market will follow the Calvo nominal price rigidity, where every time period certain number firms $(1-\theta)$ will change their prices, while some of them (θ) will leave their prices the same as in the previous period. Following this intermediate good firms will need to maximize their function below

$$max_{P_t^*} \sum_{k=0}^{\infty} \theta^k E_t \left(\Lambda_{t,t+1} (P_t^* Y_{t+k}(i) - W_{t+k} Y_{t+k}(i)) \right) \tag{18}$$

subject to the demand function of the intermediate good, equation (13). FOC of their maximizing problem will be as followed

$$\sum_{k=0}^{\infty} \theta^k E_t \left(\Lambda_{t,t+1} Y_{t+k}(i) \left(P_t^* - \frac{\epsilon}{\epsilon - 1} W_{t+k} \right) \right) = 0 \,. \tag{19}$$

In the equation (19), we can see that the price of the stock price today will be maximized only if the expected profit of the intermediate good firm will be maximized, following the maximization problem above.

3.4 Monetary Policy and the Central Bank

In this model, monetary policy will follow a simple rule of inflation and output gap reaction, called the Taylor rule

$$i_t = i^* + \Phi_\pi(\widehat{\pi_t}) + \Phi_x(\widehat{x_t}) + v_t \,. \tag{20}$$

In this Taylor rule, i^* stands for the steady state interest rate, while $\widehat{\pi_t}$ and $\widehat{x_t}$ represents the deviation of the rate of inflation from the steady state and the real GDP deviation from the potential output. The last component in the equation (20) is the exogenous component, which follows the autoregression process

$$v_t = \rho_v v_{t-1} + \varepsilon_t^{\,v} \tag{21}$$

where ${\varepsilon_t}^{v}$represents the monetary policy shock and ρ_v denotes the persistence of the shock.

3.5 Equilibrium Conditions

First, I am going to set the equations, that are going to represent the market clearing conditions in the economy. I have to mention, that in this model aggregate, per worker and per capita values will not be the same as in most of the New Keynesian models. For the goods market, the next set of market clearing conditions will be required,

$$Y_t = {N_t}^{w} C_t(j) + {N_t}^{r} D_t(j) \tag{22}$$

in per worker terms written as,

$$Y_t^{\,p} = C_t(j) + \varphi D_t(j)\,. \tag{23}$$

Labor market clearing conditions will be calculated as

$$L_t(j){N_t}^{w} = \int_0^1 N_t(i)di = N_t \tag{24}$$

in per worker terms as,

$$L_t(j) = \frac{N_t}{{N_t}^{w}} = Y_t^{\,p}. \tag{25}$$

Due to the fact, that in the equilibrium agents would not be able to trade assets among themselves and that there would be no transactions between different households, the two next conditions will be satisfied,

$$B_t = 0 \tag{26}$$

$$S_t(i) = 1 \tag{27}$$

By combining the budget constraints of both cohorts in period *t*, I got,

$$Y_t^{\,p} = C_t(j) + \varphi D_t(j) = \frac{W_t}{P_t} L_t(j) + Div_t\,. \tag{28}$$

On the stock market, intermediate goods firms will pay the total real dividend following the next conditions,

$$Div_t = \int_0^1 Div_t(i)di \tag{29}$$

$$Q_t = \int_0^1 Q_t(i)di \tag{30}$$

3.6 Steady State and Log-Linearization of the Model

To be able to analyze the effects of ageing on the monetary policy and on the whole economy I am going to log-linearize the model around the steady state. First, I am going to calculate the steady state values for different variables and then I am going to calculate the IS-curve and the Phillips curve through my log-linearization process.

In the model, the next steady state values for good market in per worker terms, real marginal cost, supply condition, interest rate, per worker old consumption, and dividends will be calculated as,

$$y^* = c^* + \varphi d^* \tag{31}$$

$$w^* - p^* = \frac{1}{\mu} \tag{32}$$

$$c^{*-\sigma} = \mu {y^*}^{\Psi} \tag{33}$$

$$\left(\frac{d^*}{c^*}\right)^{\sigma} = \beta(1 + i^*) \tag{34}$$

$$\varphi d^* = y^* \left(1 - \frac{1}{\mu}\right)\left(\frac{1 + i^*}{i^*}\right) \tag{35}$$

$$div^* = y^* \left(\frac{\mu - 1}{\mu}\right). \tag{36}$$

3.6.1 Log-Linearization

The whole log-linearization process of the model will be done around the zero inflation steady state values. First, I am going to log-linearize the demand side of the economy to get the IS-curve. By log-linearization of the FOCs of workers maximization problems, equations (7), (8), and (9), I got the next set of equations,

$$\hat{w}_t - \hat{p}_t = \psi \hat{l}_t + \sigma \hat{c}_t \tag{37}$$

$$\hat{c}_t = E_t(\hat{d}_{t+1}) - \frac{1}{\sigma}(\hat{\imath}_t - E_t(\pi_{t+1})) \tag{38}$$

$$-\sigma\hat{c}_t = -\sigma\hat{d}_{t+1} + \frac{i^*}{1+i^*}\widehat{div}_{t+1} + \frac{1}{1+i^*}\hat{q}_{t+1} - \pi_{t+1} - \hat{q}_t \tag{39}$$

$$\widehat{div}_t = \hat{y} + \frac{1}{\mu - 1}(\widehat{w}_t - p_t)\,. \tag{40}$$

Equation (37) represents the labor supply decision made by a young agent at time *t*, while equation (38) denotes the linear Euler equation of young agent also in time *t*. Since Euler equations show the connection between the consumption of a young agent and consumption of an old agent, this will not be the IS-curve in the model. To calculate the model IS-curve I took the intertemporal budget constraint,

$$D_{t+1} = \left(\frac{W_t}{P_t}\,L_t(j) - C_t(j)\right)\frac{(1+i_t)}{(1+\pi_{t+1})} \tag{41}$$

and I log-linearized it around the steady state,

$$\hat{d}_{t+1} = (1+i^*)\frac{1}{\mu}\frac{y^*}{d^*}\left(\widehat{w}_t - \hat{p}_t + \hat{l}_t(j)\right) - (1+i^*)\frac{c^*}{d^*}\hat{c}_t + (\hat{\imath}_t - \pi_{t+1})\,. \tag{42}$$

After that, I took the Euler equation, equation (9), and put it into the equation above to get,

$$\begin{aligned}\hat{c}_t + \frac{1}{\sigma}(\hat{\imath}_t - E_t(\pi_{t+1})) &= (1+i^*)\frac{1}{\mu}\frac{y^*}{d^*}\left(\widehat{w}_t - \hat{p}_t + \hat{l}_t(j)\right) - (1+i^*)\frac{c^*}{d^*}\hat{c}_t \\ &\quad + (\hat{\imath}_t - \pi_{t+1})\,.\end{aligned} \tag{43}$$

Further, I used the steady state values of goods in per worker terms and per worker consumption, rearrange it and get the next set of steady state values, written as,

$$\frac{c^*}{d^*} = \varphi\frac{1+i^*-\mu}{(\mu-1)(1+i^*)} \tag{44}$$

$$\frac{y^*}{d^*} = \varphi\frac{i^*\mu}{(\mu-1)(1+i^*)}\,. \tag{45}$$

Then I put those steady state conditions in equation (43),

$$\hat{c}_t\left(1-\frac{\sigma\varphi i^*}{(\mu-1)}+\frac{\varphi(1+i^*-\mu)}{(\mu-1)}\right) = \frac{\varphi i^*(1+\psi)}{(\mu-1)}\hat{y}_t+\left(1-\frac{1}{\sigma}\right)\left(\hat{\imath}_t-\pi_{t+1}+\frac{1}{\sigma}E_t(\pi_{t+1})\right). \quad (46)$$

To get the IS-curve, I took the steady state value of the total production per worker, which is going to be the same as a sum of consumption by workers and by retires.

$$\hat{y}_t = \frac{c^*}{y^*}\hat{c}_t(j)+\varphi\frac{d^*}{y^*}\hat{d}_t \quad (45)$$

To finally get the wanted IS-curve I rearrange the equation (46) and express the consumption of both cohorts,

$$\hat{c}_t(j) = \frac{\varphi i^*(1+\psi)}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)}\hat{y}_t + \frac{(\mu-1)}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)}\left(\frac{\sigma-1}{\sigma}\hat{\imath}_t-\pi_{t+1}+\frac{1}{\sigma}E_t(\pi_{t+1})\right) \quad (46)$$

$$\hat{d}_t(j) = \hat{c}_{t-1}(j)+\frac{1}{\sigma}(\hat{\imath}_{t-1}-\pi_t)-\pi_t+E_{t-1}(\pi_t) \quad (47)$$

which will be put in the IS-curve, equation (44).

In order to fulfill the model, the Phillips curve also needs to be calculated. I looked at the supply side of economy, where it holds that $\hat{y}_t = \hat{l}_t$. First, I got the aggregate price index,

$$P_t = (\theta(P_{t-1})^{1-\epsilon}+(1-\theta)(P_t{}^*)^{1-\epsilon})^{\frac{1}{1-\epsilon}} \quad (48)$$

And I divided it by P_{t-1} to get

$$\left(\frac{P_t}{P_{t-1}}\right)^{1-\epsilon} = \theta+(1-\theta)\left(\frac{P_t{}^*}{P_{t-1}}\right)^{1-\epsilon} \quad (49)$$

which can also be written as,

$$(\Pi_t)^{1-\epsilon} = \theta+(1-\theta)\left(\frac{P_t{}^*}{P_{t-1}}\right)^{1-\epsilon} \quad (50)$$

Then I log linearize it around the zero-inflation steady state

$$\pi_t = (1-\theta)(p_t{}^* - p_{t-1}) \tag{51}$$

or

$$p_t = (1-\theta)p_t{}^* + \theta p_{t-1}\,. \tag{52}$$

Then I took the equation (19) and I divided it by P_{t-1}

$$\sum_{k=0}^{\infty} \theta^k E_t \left(\Lambda_{t,t+1} Y_{t+k}(i) \left(\frac{P_t{}^*}{P_{t-1}} - \frac{\epsilon}{\epsilon - 1} W_{t+k}{}^r \frac{P_{t+k}}{P_{t-1}} \right) \right) = 0\,. \tag{53}$$

and log-linearized it around the zero-inflation steady state condition

$$p_t{}^* - p_{t-1} = (1-\theta\beta J) \sum_{k=0}^{\infty} (\theta\beta J)^k E_t(\widehat{mc}_{t+k} + p_{t+k} - p_{t-1}) \tag{54}$$

where it holds that $\frac{P_t{}^*}{P_{t-1}} = 1$, $\pi_{t-1,t+k} = 1$, $Y_{t+k}(i) = y^*$, $W^* = \frac{1}{\mu}$, $\Lambda_{t,t+1} = \beta^k J^k$ and $J = \left(\varphi \frac{1+i^*-\mu}{(\mu-1)(1+i^*)}\right)$.

By reoptimizing the optimal price setting rule, I got

$$p_t{}^* = \theta\beta J E_t(p_{t+1}{}^*) + (1-\theta\beta J)\widehat{mc}_t + (1-\theta\beta J)p_t\,. \tag{55}$$

To get the final Phillips curve I combine the equations (51) and (55), where I plug the $p_{t+1}{}^*$ in it to get

$$\pi_t = (1-\theta)\left(\theta\beta J E_t\left(\frac{\pi_{t+1}}{(1-\theta)} + p_t\right) + (1-\theta\beta J)\widehat{mc}_t + (1-\theta\beta J)p_t - p_{t-1}\right) \tag{56}$$

and

$$\pi_t = \tilde{\beta} E_t(\pi_{t+1}) + \tilde{k}\widehat{mc}_t \tag{57}$$

where $\tilde{\beta} = \beta J$ and $\tilde{k} = \frac{(1-\theta)(1-\theta\,\tilde{\beta})}{\theta}$. Since marginal costs are calculated as a difference between the nominal wage and price, I got the next expression

$$mc_t = w_t - p_t = \sigma c_t + \psi l_t = \sigma c_t + \psi y_t \tag{58}$$
$$= \left(\frac{\varphi i^*(1+\psi)\sigma}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)} + \psi\right) {y_t}^p + \frac{(\mu-1)\sigma}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)}\left(\frac{\sigma-1}{\sigma}\hat{\imath}_t - \pi_{t+1} + \frac{1}{\sigma}E_t(\pi_{t+1}) - \rho\right)$$

where $\rho = log\tilde{\beta}$. Then I put the equation for the natural level of output in the equation in order to get the relationship between the output gap (x_t) and the marginal costs.

$$-log(\mu) = \left(\frac{\varphi i^*(1+\psi)\sigma}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)} + \psi\right) {y_t}^n \tag{59}$$

$$\widehat{mc}_t = \left(\frac{\varphi i^*(1+\psi)\sigma}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)} + \psi\right) x_t + \frac{(\mu-1)\sigma}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)}\left(\frac{\sigma-1}{\sigma}\hat{\imath}_t - \pi_{t+1} + \frac{1}{\sigma}E_t(\pi_{t+1}) - \rho\right) \tag{60}$$

Lastly, I put the expression for the marginal costs, equation (60), into equation (57) to get the final dynamic Phillips curve of the model.

$$\pi_t = \tilde{\beta}E_t(\pi_{t+1}) + \tilde{k}\left(\left(\frac{\varphi i^*(1+\psi)\sigma}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)} + \psi\right)\hat{x}_t\right) + \tilde{k}\left(\frac{(\mu-1)\sigma}{(\mu-1)(1-\varphi)-\varphi i^*(\sigma-1)}\left(\frac{\sigma-1}{\sigma}\hat{\imath}_t - \pi_{t+1} + \frac{1}{\sigma}E_t(\pi_{t+1}) - \rho\right)\right) \tag{61}$$

4 ANALYSIS OF THE POPULATION AGEING EFFECTS ON THE MONETARY POLICY

In this section I am going to test the model to analyze the effects of population ageing on monetary policy and other macroeconomic variables. By calculating the impulse

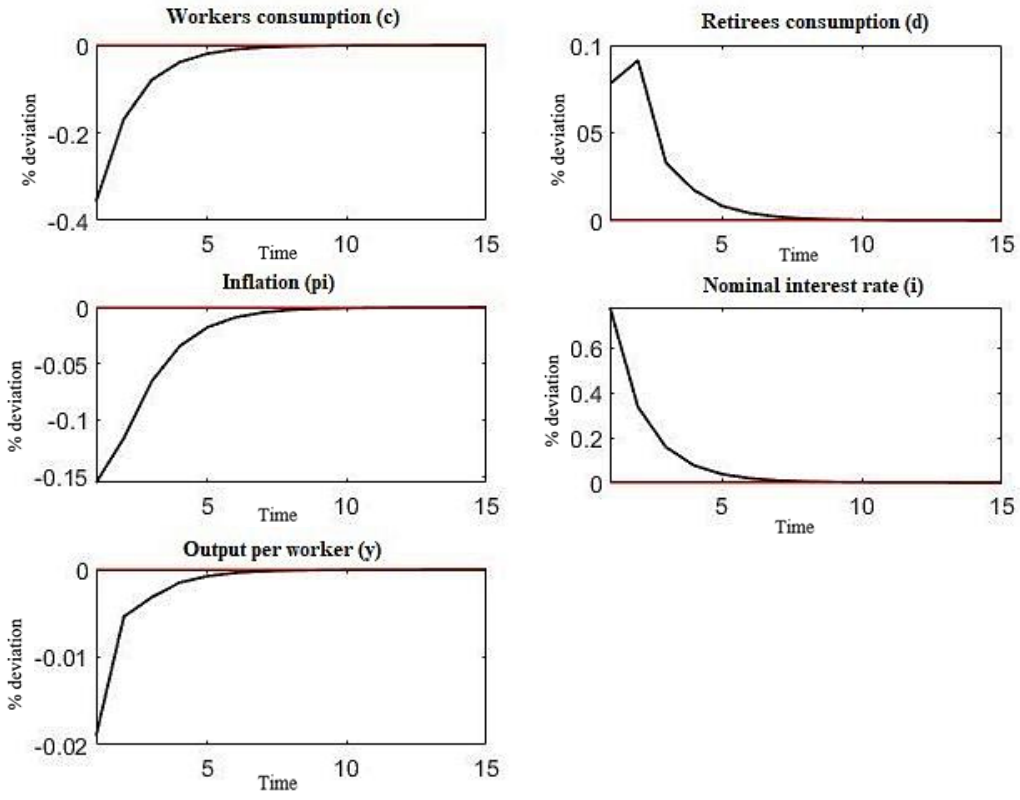
responses to the tightening monetary policy shock ($\varepsilon_t{}^{v}$), introduced in the model, I am going to see how certain variables will react to it. I am going to look at the responses of five variables, consumption of workers and retirees, interest rate, output gap per worker, and inflation.

First, I will show the results of the impulse responses to the monetary policy shock in the economy, where the old-age dependency ratio will be equal to 70%, meaning that the population of this economy will be old. Lastly, I am going to show the differences in impulse responses to selected variables between the old population and the young population, in which the old-age dependency ratio will be only 25%. This will give me clear evidence of whether monetary policy efficiency will be weakened or not, due to the effects of population ageing.

4.1 Impulse Responses to the Monetary Policy Shock in the Economy with the Old Population ($\varphi = 0.7$)

Down below, we can see Figure 6, which shows the impulse responses of different variables to the monetary policy shock in the economy with an old population.

Figure 6: Impulse responses to the monetary policy shock in the old population ($\varphi = 0.7$)



Source: Own work.

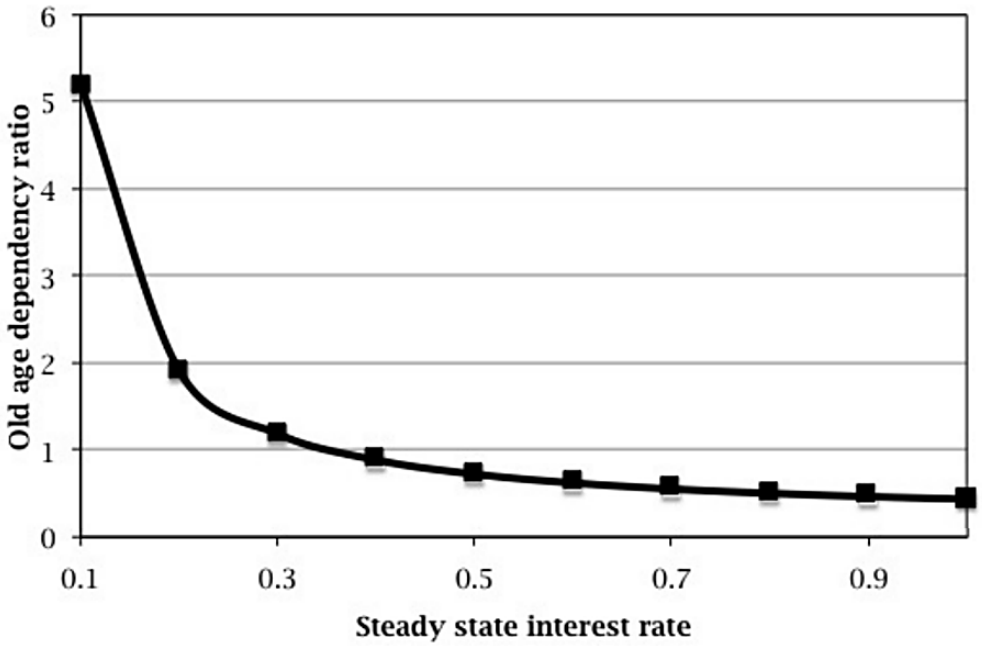
If we first look at the response of workers' consumption (c) to the monetary policy shock we can see that they will decrease their consumption. After some time, their consumption will start to increase, which can be connected to the decreasing interest rate in the economy. Since interest rate will decrease in the economy, workers will adjust their financing behavior allowing them higher consumption in the next few periods. Due to decreasing interest rate, they will allocate less of their monthly income into savings and more into consumption. Another explanation for why the consumption of workers will decrease at the time of the shock is connected to the fall in the output gap per worker, which will negatively affect the labor market. Production in the economy will fall, leading to the tightening of the labor market and real wage decrease. Further on, decreased real wages will lead to a decrease in marginal cost, which will negatively affect inflation.

As we can see, the consumption of retired people (d) will react in the opposite direction. Monetary policy shock will positively affect their consumption. Indirect consumption response of the retirees will happen due to the fact that old and, retired people set their consumption based on the previous period information. Since their consumption behavior was set on the previous period's information, the change in interest rate happening now will have no effect on their response. Since their consumption behavior will be set based on the information of presented variables from the previous period, a different response to the retirees' consumption will be visible. In Figure 6, we can also see that there is a peak in the consumption response of retirees. This peak is due to the fact that retirees decide about their consumption response at the time, when they were workers. Since in the model, only two periods are considered, the monetary policy shock occurs when they are workers, leading to such a reaction in the next period, when they will be already retired. Due to the positive, tightening monetary policy shock, they will reduce consumption (as said before, consumption of workers will decline) and increase their savings. In the next period, when they retire, they will use their increased savings from the last period, which explains the peak in their consumption response to the monetary policy shock. After they will use all of their savings (after the peak in their response), the decrease in their consumption will be visible (Kantur, 2013, page 18).

As we already learned in chapter 2.3, where we mentioned the possible effects of population ageing on the movement of interest rates, we can also see from the graph in Figure 6 that the effects of population aging will harm the level of average changes of interest rates (i). The positive shock of the monetary policy will lead to the reduction of both nominal and real interest rates, mostly due to the changed consumption and saving habits of agents in the economy. A higher old-age dependency ratio will negatively affect the nominal interest rate since the steady state interest rate will follow equation 34. Negative effects of population ageing on nominal interest will happen due to the increased savings of workers and their reduction in consumption as a response to the monetary policy shock. As we said in the previous paragraph, workers will reduce their consumption and increase their savings, when a monetary policy shock will occur, since

they will want a bigger wealth and more money in the next period, when they will be retired, to finance their retirement consumption. Another explanation for the decrease in the interest rate is connected to the changed number of workers in the labor market. In an aged population, the labor market will have a smaller number of workers, leading to the excess demand for labor, which will negatively affect the ratio between the labor and capital. Population ageing will decrease the labor supply, but on the other hand, capital will become more abundant, which will lead to a decrease in the real interest rate. As we can see in Figure 7, there is clear evidence of a negative correlation between the old-age dependency ratio and the steady-state interest rate.

Figure 7: Relation between the steady-state interest rate and the old-age dependency ratio



Source: Kantur (2013).

Similar to the consumption of workers, output per worker will also decrease due to the monetary policy shock in the economy. This will happen due to the fact that in the selected model, labor is the only input on the production site of the economy. Therefore, labor will always follow the direction of the output. A negative response of the output per worker will occur due to the fewer and fewer workers on the labor market, leading to lower production in the economy. As we said before, lower production and lower output will tighten the labor market, meaning that the real wage will decrease, leading to a reduction in the consumption of workers in the economy. The results from the model are consistent with many already mentioned studies, which also proved that the effects of population ageing will harm production. A decrease in the population growth rate together with an increase in the old-age dependency ratio, will negatively impact production, which will consequently increase the output gap in the economy. All of this can ultimately have an

additional negative impact on the aggregate potential output and the economic growth rate.

Lastly, we can look at the impulse responses of inflation to the monetary policy shock. As we can see, there will be a negative response of inflation to monetary policy shock that will happen since there will be a decrease in the real wage due to the tightening of the labor market. Monetary policy shock will lead to a decrease in marginal costs since the production in the economy will also lower due to fewer and fewer workers on the labor market. Decreased marginal costs will then negatively affect the inflation, meaning there will be a big deflationary pressure in the aged economy. Deflationary pressures will also happen due to the changing patterns in consumption and savings. Since the consumption of workers will decrease and their savings will increase, lower inflation will be visible. Together with all that, the reduction in output per worker, which will be below the potential output, will also negatively affects inflation, leading to deflationary pressures in the economy. The results, therefore, coincide with the findings of various studies, which managed to prove that population ageing will have a negative effect on the inflation rate.

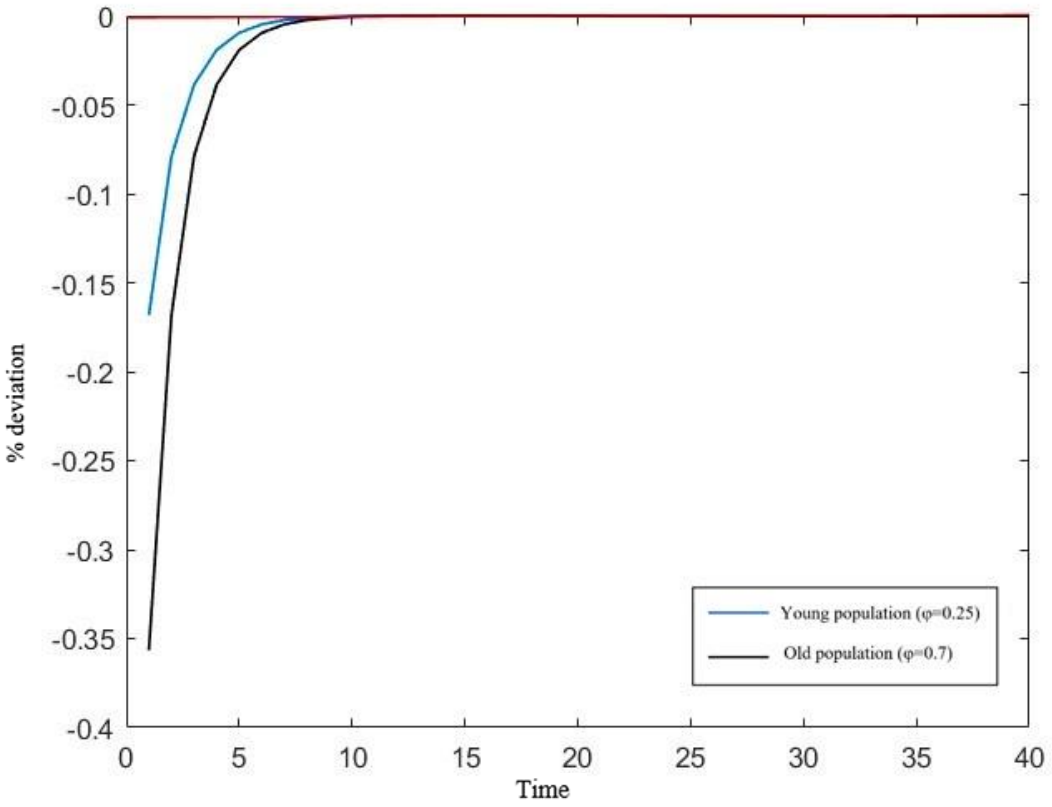
4.2 Analysis of the Monetary Policy Efficiency

To find how population ageing will affect monetary policy and its efficiency, I analyzed the impulse responses to two different models, with different old-age dependency ratios. The first one was the same model with, the same population as in chapter 4.1, where the old-age dependency ratio was 70% (φ=0.7). Since there is 70% of older people and only 30% of younger people in this population, we can treat it as an old population. Next, I chose the young population, where the old-age dependency ratio was only 25% (φ=0.25). By analyzing the impulse responses of both populations with the same model, I could see how population ageing will affect certain macroeconomic variables and most importantly, how it will affect monetary policy.

First, I am going to look at the reaction to consumption by workers. As we can see from Figure 8, in both populations tightening monetary policy shock will lead to a fall in consumption by workers. However, the magnitudes of the responses will be different. In the older population, young people or workers will react more strongly to the presented shock. This will happen mainly due to the higher interest rate sensitivity of young people in the older population. Due to the change in the economic ratio between the borrowers and lenders and different inflation rate, the young population will react more to the older population than to the younger one. Going back to the model, let us' mention once again that in this model only two time periods are considered. In the first period, agents are considered workers, while in the second period, they become pensioners or retirees. In their first period, agents enter the labor market, which brings them monthly labor income, which they allocate to finance their consumption, and some of it, they also allocate to

savings. Part of their monthly income is also allocated to the purchase of bonds and the firm's stocks, which bring them positive returns during the retirement period. Following this, we can see the importance of interest rate and inflation, on the reaction of young people's consumption to a monetary shock. In the case of low inflation, deflation, and a positive interest rate, which is typical for an older population, the wealth of older people will increase, which will affect the greater response of young people in the older population. They will become more sensitive to the interest rate as the old-age dependency ratio increases, precisely because of the motive for increasing wealth in their later life. They will know that their retirement will be longer and that they will need more money for their consumption, so they will start to decrease their consumption already in their young age to spend more money on stocks and bonds, which will bring them higher wealth in the next period, in the retirement. All this together will give us the result that young consumer will react more strongly to the monetary policy shock in the case of the older population, mainly due to the higher interest rate sensitivity and bigger consumption smoothing over the lifetime period of young people.

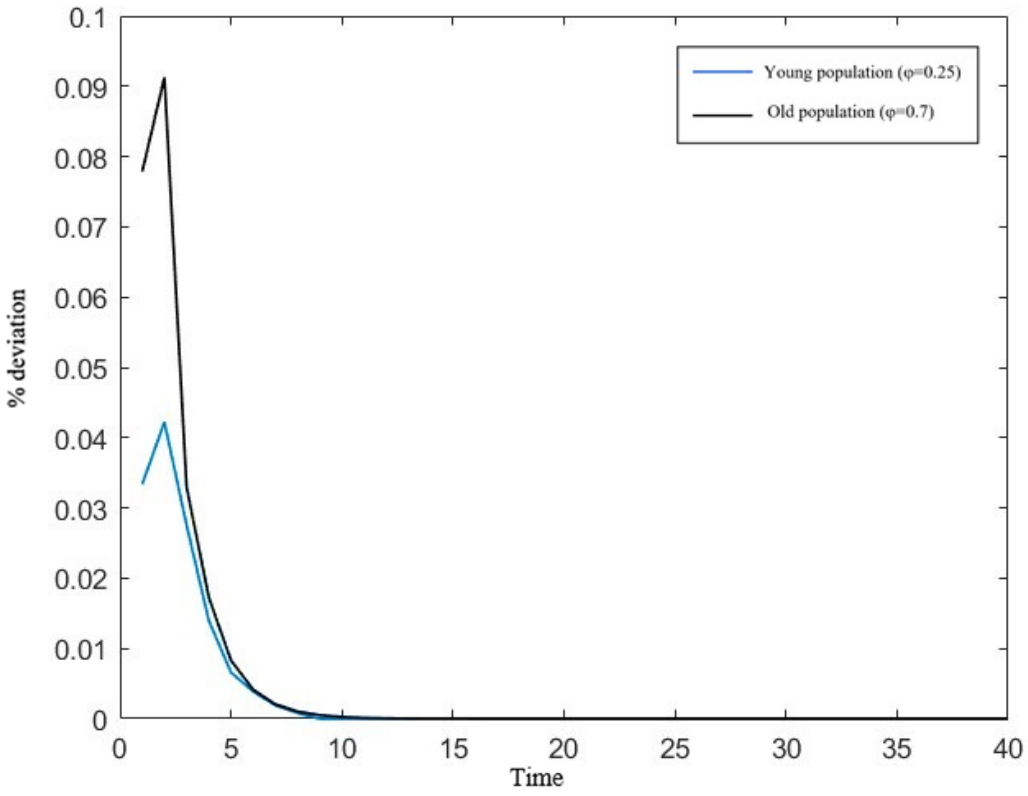
Figure 8: Impulse responses of workers' consumption to the monetary policy shock in the old and young population



Source: Own work.

On the other hand, from Figure 9, we can see that the consumption of retirees will react more strongly in the case of an old population. This will happen because, in the older population, the wealth of older people will be higher due to the higher deflation in this economy. Higher deflation and bigger interest rate sensitivity of young people in the older population will, therefore, lead to a stronger reaction of consumption by retirees. Since deflation will increase their wealth, they will be able to react more when the tightening monetary policy shock will occur. Bigger and higher wealth as the result of higher deflation will allow them to spend more on consumption in the time of the shock, even if their retirement period will be longer. They will hold more money, for a longer retirement period, which will allow a stronger consumption response of retirees in the older population, compared to the younger one.

Figure 9: Impulse responses of retirees' consumption to the monetary policy shock in the old and young population

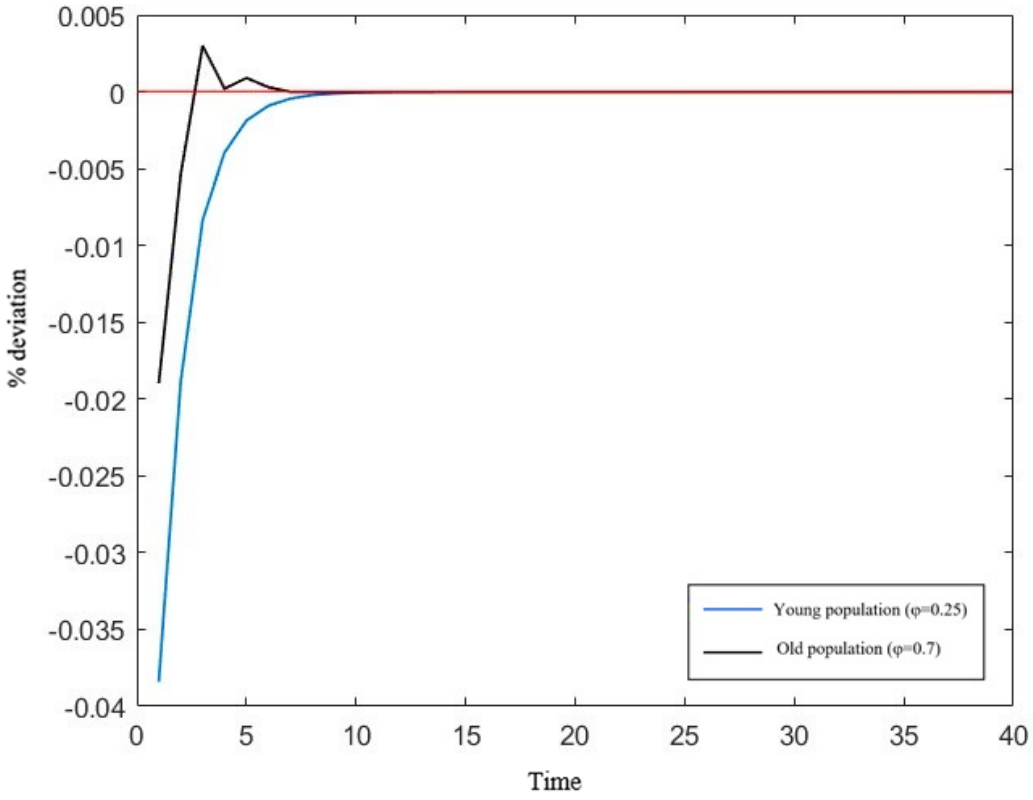


Source: Own work.

Figure 10 shows the impulse responses of output gap per worker to the tightening monetary policy shock. We can see that the output gap per worker will decrease in both economies due to the fall in the demand side at the time of the shock. In the older population, the output will decrease less at the time of the monetary policy shock, while in the next periods, after the shock, the weaker response can be noticeable. Some period

after the shock, the output gap per worker will be smaller in the case of an older population, than in the case of the younger population. Therefore, a positive effect on output per worker and output gap per worker may happen in the case of the older populations. As said before sometimes, in the older population we can observe less effective negative effects of ageing on GDP and the overall output gap, mostly due to more older workers in the labor market. A large number of older workers in the labor market will positively affect the labor supply, leading to a smaller fall in output overall. Since in this model, an agent can only work in their first period of life, this motive cannot be considered. To explain why population ageing can positively affect the output gap per worker, we need to look back at the life cycle hypothesis. As said before, workers allocate part of their labor income to savings, which they will use to finance their consumption during the retirement period. In line with this statement, I can mention that in the case of an older population, where life expectancy is considered to be higher, there may be a positive reaction from workers, who will increase their work to increase their monthly income, which will enable them bigger savings and ability to finance their consumption for the longer retirement period. Said differently, workers will start to work more in order to gain more money, allowing them to save more for their next period. Increased savings will, therefore, mean more money for their consumption in retirement since they will hold more wealth due to increased savings from bigger labor income one period before. Higher labor input, some period after the shock, will, therefore, positively affect the production and output, leading to a smaller response of output gap per worker in the older economy.

Figure 10: Impulse responses of the output gap per worker to the monetary policy shock in the old and young population

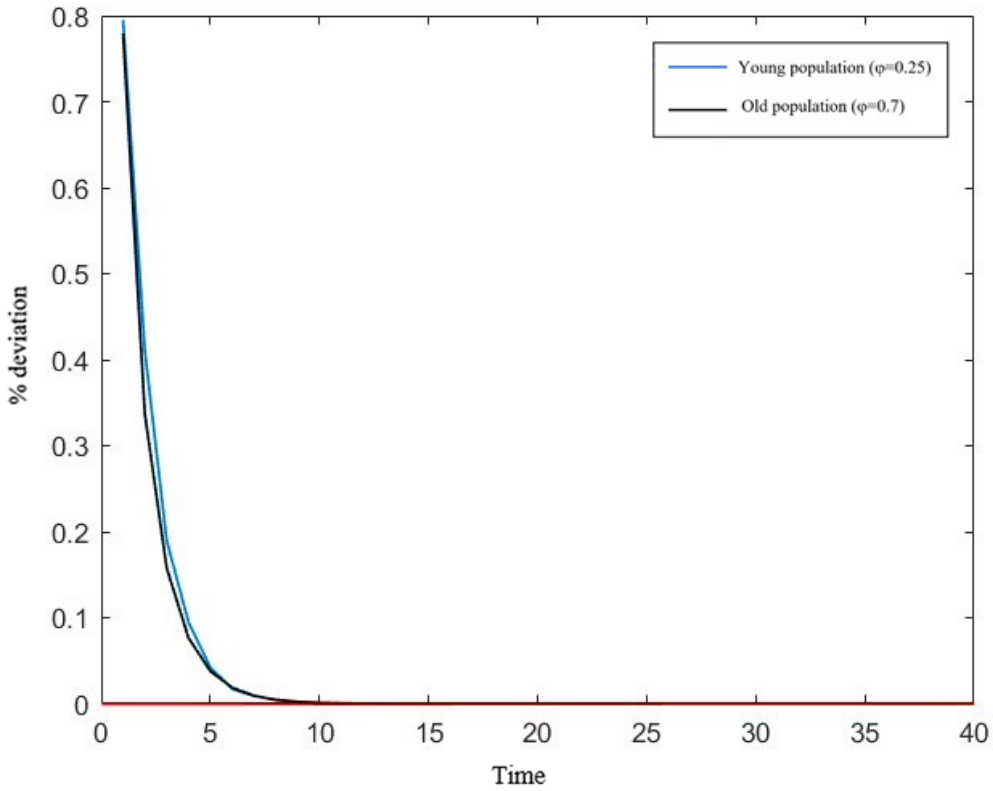


Source: Own work.

For the last two variables, inflation, and interest rate, we can see that the impulse responses to tightening monetary policy shock of nominal interest rate will be quite the same, no matter the ageing structure of the population. Figure 11 shows the impulse response of the nominal interest rate to the shock. In Figure 11, we can see the small positive spike of the nominal interest rate at the beginning, followed by a decrease over the years, falling back to 0% steady-state value. As we can see, the problem of hitting ZLB may occur in both economies, meaning the monetary policy efficiency will be decreased. Since older people prefer low and stable inflation, which will lead to a decrease in the nominal interest rate, the probability of this ZLB problem can be a bit higher in the older population. Lastly, as we can see from Figure 12, deflation of the older population will be higher than in the case of the younger population. Higher deflation in the economy with an older population can be explained through the labor market channel. As said many times already, young people will supply their labor to get some labor income that will be redistributed to their consumption and savings. Afterward, together with the increased longevity in the older population, the problem of excess supply will happen in the labor market. Young agents will follow the motive of higher wealth in their second period of life, the retirement period, which will allow them better consumption over the longer

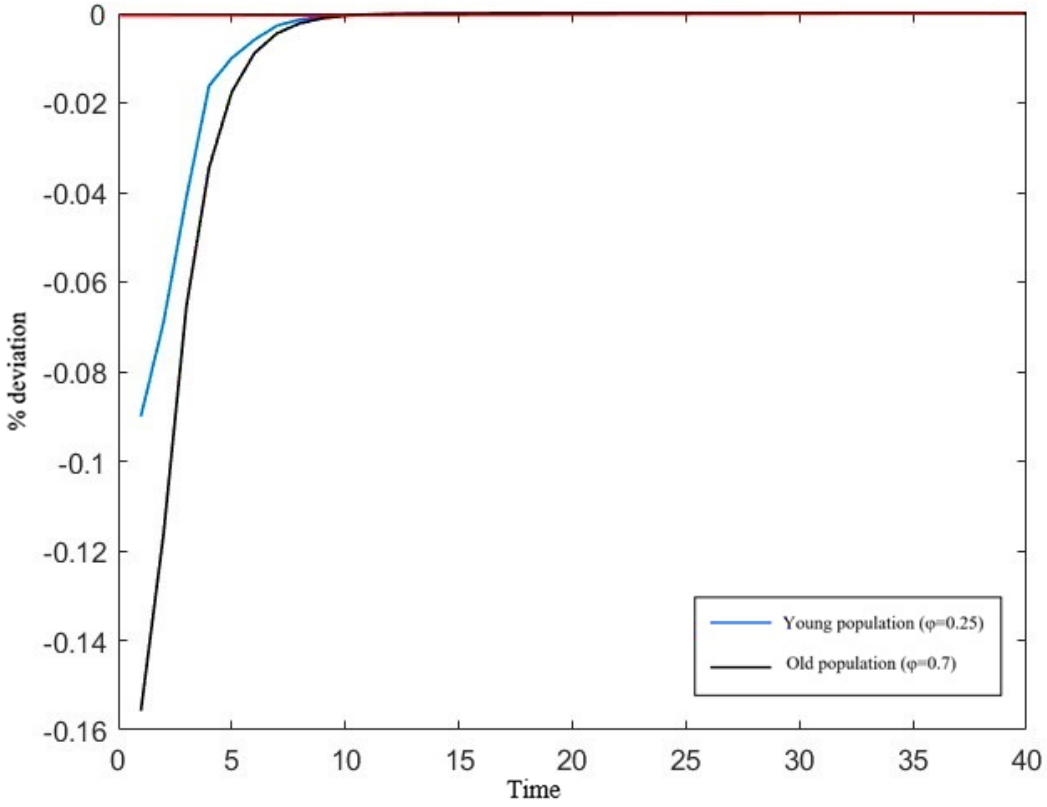
retirement period. Afterward, they will start to supply more labor in the labor market. More labor, will negatively affect wages. Since the inflation response will follow the response of wages, we can expect higher deflationary pressures in the economy with the older population. Another explanation for higher deflationary pressures in the older population is connected to the reduced savings rate among the older agents. As we know until now, young people will save some of their labor income for their retirement period. As they will enter the retirement period, they will start using these savings and, get different returns for the stocks and bonds that they bought as a young agent in the previous period, with which they will finance their consumption. We can see that the savings rate of younger agents compared to the savings rate of older agents will be much higher. The decreased savings rate in the older population will, therefore, put a negative effect on inflation, causing higher deflationary rates as a response to the tightening monetary policy shock. The third explanation for why the deflation rate can be higher in the economy with the older population comes from the difference in the preferences of older agents. Older agents prefer stable and low inflation, which will protect their savings and the whole wealth used to finance their consumption in the retirement period. The desire to preserve the value of assets and wealth of older agents will, therefore, trigger negative effects on the inflation rate, leading to deflation.

Figure 11: Impulse responses of nominal interest rate to the monetary policy shock in the old and young population



Source: Own work.

Figure 12: Impulse responses of inflation to the monetary policy shock in the old and young population



Source: Own work.

To sum up, all the effects of the population ageing on monetary policy, we can say that ageing will lead to a lower level of inflation and lower output per worker, together with a higher consumption response of young agents and old ones. Due to the presented effects that the ageing of the population will have on the selected macroeconomic variables, it will be possible to see a greater decrease in the sacrifice ratio between the output gap and inflation in the older population. Following all this, the effectiveness of the monetary policy will decrease as the population ages. We can see that the monetary policy will lose its power to influence the output gap and that the problem of inflation targeting may also arise (Kantur, 2013).

The presented results, therefore, confirm numerous studies that have also shown that the ageing of the population can have a negative impact on monetary policy and its effectiveness. The ageing of the population, mainly due to changes in the behavior of individuals in consumption and saving, has a strong impact on monetary policy and its effectiveness. The increase in life expectancy and, at the same time, the decrease in the birth rate, which has a positive effect on the ageing of the population of each country, ensure the reorganization of the individual's money, which leaves a strong mark on

monetary policy. The changed organization of money, through its influence on the formation of interest rates and the rate of inflation, has a negative impact on the operation of monetary policy and its effectiveness. Accordingly, it is, therefore, important that the effects of population ageing on the monetary policy and its effectiveness will be analyzed immediately, as this is the only way that allows the reduction of these negative effects. This can already be seen in many countries, but Japan stands out, including the process of population ageing in both the creation of monetary and fiscal policy. The formulation of a new monetary policy more adapted to the changed habits of the elderly population will, thus, be decisive in minimizing the negative effects on the overall macroeconomic situation and on the effectiveness of many macroeconomic policies, monetary and fiscal policy.

CONCLUSION

In my master's thesis, I presented the effects of population ageing on monetary policy and its efficiency. I described five channels through which the ageing of the population can affect monetary policy. To confirm the possible negative effects of population ageing on monetary policy, I used a two-period DNK model with overlapping generations, written by Kantur (2013). By comparing the impulse responses of two models with different age structures, I showed that population ageing can affect monetary policy and its efficiency in a negative way.

According to scientific literature, the ageing of the population represents one of the most important challenges in the field of macroeconomic policy formulation. The effects of population ageing can be detected in the field and operation of fiscal policy in connection with the operation and efficiency of the public pension system, as well as in the field of money and related monetary policy. By studying the scientific literature on the effects of population ageing on macroeconomic policies, I found that this problem can bring quite a few changes to the fiscal environment and the monetary policy environment. The most noticeable effects of population ageing can occur primarily in the area of consumption and savings. Due to the increased life expectancy, more and more individuals decide to save more, which also requires a better organization of consumption itself throughout their entire life and better consumption smoothing. In a population that is struggling with the problem of population ageing, we can expect an increase in the savings rate in the initial phase of the ageing process, followed by a decrease in the following years. The reduction in the saving rate occurs, because of a completely normal process. When individual agents enter their retirement years, they receive lower monthly income, which in turn affects the lower amount of savings. A smaller amount of their monthly income is normally distributed to the financing of their consumption, leaving a smaller amount of money to be saved. Due to the changed credit and wealth structure, the pronounced effects of population ageing can also be felt in the area of wealth and credit. In relation to monetary policy, the ageing of the population, as a matter of course, represents one of the

top five modern challenges, precisely in the field of interest rate and inflation rate formation. In my master's thesis, with the help of the literature already written, I found out that the interest rate channel and the inflation channel can be strongly negatively affected by the presented phenomenon of population ageing. In order to find out what effects the ageing of the population will bring to the field of monetary policy I used the two-period DNK model with overlapping generations. The demand side of the model includes two agents, i.e., workers and retirees both maximizing their utilities subject to their budget constraints. However, on the supply side, two types of firms are assumed, where producers are setting their prices following the famous a la Calvo price setting. To analyze the effects of population ageing, monetary policy was set to follow the basic Taylor rule, including inflation and output gap targeting.

First, I solved the chosen two-period DNK model with overlapping generations. After this, I calculated the impulse responses of chosen variables to tightening monetary policy shock based on the old population with the old-age dependency ratio equal to 70%. I found that the consumption of workers, inflation rate, and output per worker will decrease due to the presented shock. However, the response to the shock will be in the opposite direction for the consumption of retirees and the interest rate. These two variables will react in the opposite direction; the tightening monetary policy shock will affect them positively. The presented results showed me that the ageing of the population can be responsible for the negative pressures on the economy and its monetary policy. Due to the changed consumption and saving habits of agents in the ageing population, it will be possible to detect negative effects in the area of inflation and interest rates. The ageing of the population will have a negative impact on the labor market, where there will be a decrease in productivity and real wages, as well as a decrease in related marginal costs. The presented negative effects will then trigger a wave of negative impacts on inflation and the interest rate. Through these findings, I got the answer to my second hypothetical question, where I ask myself whether population ageing will affect inflation and interest rate in a negative way.

Second, I compared the impulse responses of the previously presented variables to a tightening monetary policy shock between two different populations. One had an old-age dependency ratio equal to 25%, and one had the same percentage as before, 70%. My results showed that the ageing population problem will cause more negative impulse responses of workers' consumption, followed by more negative responses of the inflation rate. On the other hand, the impulse responses of retirees' consumption and even the output gap per worker will be more positive in the older population. Positive effects of population ageing on the output gap per worker will happen due to the increased input of workers in the older population, who, due to their goal of greater savings, begin to work much more, which in turn has a positive effect on productivity itself and the output gap. Following this, the ageing of the population might have a positive effect on productivity and the output gap, simply because of higher labor input in the economy. Some scientific

papers also added that these positive effects of population ageing on productivity and the output gap can also be due to the fact, that more and more older workers are participating in the labor market. Looking at the impulse responses of inflation to the tightening monetary policy shock, the clear negative effects of population ageing on the inflation rate can be visible. The ageing of the population will lead to much greater deflationary pressures that, can seriously threaten the functioning and the whole foundation of the monetary policy. Higher deflationary pressures in the older population will arise from reasons related to the labor market, and a higher reduction in real wages and marginal costs will happen in the older population. All this together will further put more negative pressure on the inflation rate.

This study provides results consistent with the literature, meaning that the ageing of the population will negatively affect the monetary policy and its efficiency. Due to the higher interest rate sensitivity in the older population, the effectiveness of the monetary policy in controlling the output gap will be smaller. Along with that, the sacrifice ratio between inflation and output will decrease, which may lead to problems with ZLB and problems with improperly functioning monetary policy. As we can see, the results of the thesis confirm the knowledge of many studies that have already been done. The studies, believe that in the case of an ageing population, monetary policy must adapt to the new conditions on the economic floor. Due to the differences in the behavior of the older population that, can strongly influence the functioning of monetary policy, the monetary policy must recognize and include the problem of population ageing in its functioning and formulation. Incorporating the problem of population ageing into the monetary policy and its functioning can reduce the negative effects that the presented demographic process can bring to the economic environment. Including this, the appropriate formulation of the monetary policy, which will be adapted to the problem of population ageing, can also bring better, positive effects on the influence and functioning of the policy as such.

Although this study provides interesting findings, it also can be improved and extended even more, by the more realistic model. By including the fiscal policy, tax system and the whole pension system, the better effects of population ageing on the economy and on the monetary policy can be shown. Additionally, the model can also be improved by allowing more periods, that will suit real life and the whole decision-making process better. All the improvements in the model will give better results in explaining the effects of population ageing, which represents one of the leading problems of many developed countries all around the world.

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APPENDICES

Appendix 1: Povzetek v slovenskem jeziku

ANALIZA UČINKOV STARANJA PREBIVALSTVA NA MONETARNO POLITIKO

Ključna ideja moje magistrske naloge je ugotoviti ali lahko proces staranja prebivalstva vpliva na denarno politiko in njeno učinkovitost. Zaradi velikih negativnih učinkov staranja prebivalstva na preostalih makroekonomskih področjih, predvsem na področju fiskalne politike in stabilnosti javnega finančnega sistema, me je namreč zanimalo kako in v kolikšni meri lahko predstavljen demografski problem vpliva na delovanje monetarne politike in njeno učinkovitost.

Namen magistrske naloge je prikazati učinke in pomen staranja prebivalstva na denarno politiko in njeno učinkovitost. Ker v procesu staranja prebivalstva pride do močnih sprememb predvsem na področju potrošnih in varčevalnih navad, lahko pričakujemo močan učinek predvsem na kanal obrestnih mer in stopnjo inflacije. Namen mojega dela je torej s pomočjo enostavnega DNK modela prikazati učinke in posledice staranja prebivalstva v povezavi z denarno politiko, ter odkriti povezavo med staranjem prebivalstva in učinkovitostjo denarne politike.

Glavni prispevki dela so povezani z literaturo, ki raziskuje povezanost med učinki staranja prebivalstva in denarno politiko. S svojo raziskavo sem se osredotočila predvsem na učinke staranja prebivalstva na področja potrošnje, varčevanja, kreditnega kanala in kanala premoženja, ter na področje obrestnih mer in inflacijske stopnje. V magistrskem delu sem sledila naslednjim raziskovalnim vprašanjem:

- Ali staranje prebivalstva res povzroča negativne učinke na denarno politiko?
- Ali in kako staranje prebivalstva vpliva na stopnjo inflacije in obrestne mere v gospodarstvu?
- Ali bo učinkovitost denarne politike v primeru staranja prebivalstva v gospodarstvu manjša?

Za preučitev učinkov staranja prebivalstva najprej pregledam že objavljeno literaturo, pri kateri se osredotočim predvsem na učinke staranja prebivalstva na prej predstavljena področja. Zaradi povečanja stopnje preživetja in znižanja stopnje rodnosti, ki pozitivno vplivata na hitrejše staranje prebivalstva, namreč pride do številnih sprememb v obnašanju posameznih agentov. Izrazite spremembe so vidne predvsem na področju potrošnje in varčevanja, kjer se zaradi želje po boljši in lepši prihodnosti, ki bo zaradi procesa staranja tudi daljša, posamezniki začnejo nagibati k vse večjem varčevanju in skrbnejšemu organiziranju same potrošnje. Z namenom večjega varčevanja denarja, ki jim bo v času upokojitve omogočal financiranje njihove potrošnje, agenti v starajoči populaciji temu prilagodijo tudi svojo potrošnjo. Poveča se torej delež mesečnega dohodka, ki ga posamezniki namenijo varčevanju, hkrati pa se na drugi strani temu

prilagodi tudi potrošnja. Predstavljene spremembe v potrošnih in varčevalnih navadah, ki se lahko zgodijo zaradi procesa staranja prebivalstva, lahko tako privedejo do slabše reakcije potrošnje na šoke denarne politike.

Učinki staranja prebivalstva pa so vidni tudi na področju kreditiranja in premoženja. Veliko literature namreč omenja pozitivno povezavo med deležem starejšega prebivalstva v populaciji in stopnjo premoženja te populacije. Sleherno je namreč povezano s prejšnjim spoznanjem, ki govori, da staranje prebivalstva vpliva na povečanje varčevanja in posledično večjo organiziranost same potrošnje. Iz tega namreč sledi, da bo zaradi povečanja prihrankov, prišlo do večjega premoženja v starejši populaciji, kar lahko vpliva na izboljšanje premoženjskega kanala. Na drugi strani pa se stvari lahko spremenijo tudi znotraj kanala kreditiranja, ki bo zaradi staranja prebivalstva postal manj ali bolj pomemben.

Najbolj pomembni učinki staranja prebivalstva v povezavi z denarno politiko, pa se navezujejo na kanala obrestnih mer in inflacije. Dokazano je, da lahko staranje prebivalstva negativno vpliva na nominalno obrestno mero. Ti negativni učinki se zgodijo iz razloga spremenjenih inflacijskih preference starejše populacije, ki strmi k stabilnejši in nižji inflaciji, ki bo kar se da ohranila vrednost njihovih prihrankov. Negativni učinki, ki se zgodijo zaradi spremenjenih preference glede stabilnosti inflacije, pa potem negativno vplivajo še na oblikovanje nominalne obrestne mere. Zniževanje nominalne obrestne mere na drugi strani predstavlja resen problem denarni politiki, ki se zaradi tega lahko znajde v močno omejeni vlogi. Zniževanje nominalne obrestne mere, kot posledica staranja prebivalstva, lahko privede do problema ničelne spodnje meje, ki predstavlja enega izmed večjih strahov denarne politike. Spremembe v preferencah posameznikov glede potrošnje in varčevanja, ki se bodo zgodile zaradi staranja prebivalstva, pa lahko negativno vplivajo tudi na oblikovanje realne obrestne mere. Predstavljene spremembe, ki jih bo staranje prebivalstva prineslo v ekonomsko okolje, pa bodo močno vplivale tudi na oblikovanje inflacijske stopnje. Dokazano je namreč, da obstaja povezava med stopnjo inflacije in demografijo. Številne študije namreč dokazujejo, da lahko staranje prebivalstva vpliva na povečanje deflacijskih pritiskov v ekonomiji, kar močno vpliva na delovanje denarne politike. Deflacijski pritiski starajočega prebivalstva se namreč zgodijo zaradi povečane stopnje varčevanja in posledično znižanja potrošnje ljudi. V literaturi, pa lahko zasledimo tudi veliko dokazov, ki potrjujejo ravno nasprotno, in sicer, da staranje prebivalstva vpliva na povečanje inflacijske stopnje. Pozitivno povezavo med inflacijsko stopnjo in staranjem prebivalstva potrjujejo s pomočjo razlag o presežnem povpraševanju in pozitivnem vplivu staranja prebivalstva na realno plačo, ki bo pozitivno vplivala na stopnjo inflacije v gospodarstvu.

Da bi odkrila dejanske vplive, ki jih staranje prebivalstva lahko ima na denarno politiko in njeno učinkovitost, uporabim enostaven DNK model z dvema časovnim obdobjema. V modelu je populacija razdeljena na dve vrsti posameznikov, delavce in upokojence, katerih cilj je maksimiranje njihove uporabnosti glede na dane proračunske omejitve.

Prva skupina, delavci, ponujajo svojo delo na trgu dela, za kar vsak mesec prejemajo tudi plačilo. Mesečni dohodek lahko namenijo za financiranja potrošnje, določeni del pa lahko namenijo tudi na varčevanje. Varčujejo lahko s pomočjo nakupa obveznic ali delnic, ki jim bodo v času upokojitve prinašale pozitivne donose. Na drugi strani, upokojenci ne ponujajo več svoje delovne sile, se pravi, da ne prejemajo mesečnega dohodka, in se tako financirajo izključno s pomočjo pozitivnih donosov vrednostnih papirjev, ki so jih kupili v prejšnjem časovnem obdobju. Vsi agenti ob koncu zadnjega časovnega obdobja umrejo, še prej pa porabijo ves svoj denar in vse svoje prihranke. Na strani ponudbe, obstajata dve vrsti proizvajalcev, ki prav tako zasledujeta cilj maksimiranja dobička. Imamo torej proizvajalce delnih in končnih proizvodov. V panogi proizvajalcev delnih proizvodov velja nepopolna konkurenca, med proizvajalci končnih proizvodov pa popolna konkurenca. Omeniti velja, da je na strani ponudbe v model vključena tudi cenovna rigidnost, ki poskrbi za večjo primernost modela realnosti. Centralna banka s svojo denarno politiko zasleduje znano Taylorjevo pravilo, kjer zasleduje cilje glede inflacije in proizvodne vrzeli. V model je implementiran tudi šok denarne politike, s pomočjo katerega se merijo učinki staranja prebivalstva na denarno politiko in njeno učinkovitost.

Model prvotno preizkusim v primeru populacije, kjer je delež starejšega prebivalstva enak 70%. Da preučim vplive staranja prebivalstva na denarno politiko, izračunam impulzivne odzive petih izbranih spremenljivk, potrošnje delavcev in upokojencev, inflacijo, obrestno mero in proizvod na delavca. Ugotovim, da bo zaostrovani šok denarne politike vplival na znižanje potrošnje delavcev, ki se bo potem postopoma začela zviševati zaradi zniževanja nominalne obrestne mere v gospodarstvu. Negativno reakcijo na zategovalni šok denarne politike, pa bo moč zaznati tudi pri proizvodu na delavca in pa stopnji inflacije. Zaradi problemov na trgu dela, ki bo zaradi problema staranja prebivalstva, trpel za pomanjkanjem ponudbe dela, bo prišlo do upada proizvoda na delavca, negativni učinek pa bo viden tudi v končni proizvodni vrzeli. Zaradi padca delovne sile, ki bo zmanjšala mejne stroške in hkrati znižala realno plačo, bo prišlo do deflacijskih pritiskov, ki bodo stopnjo inflacije potisnili globoko v negativno smer. Na drugi strani bo potrošnja upokojencev na zaostrovani šok denarne politike reagirala pozitivno, predvsem iz razlogov večjih prihrankov, ki bodo omogočali tudi večjo potrošnjo. Nekaj časa po šoku, pa do tudi ta spremenljivka začela padati, ravno zaradi kopnenja privarčevanega denarja. Podobno potrošnji upokojencev, bo na šok reagirala tudi obrestna mera, ki se bo skozi časovno obdobje začela zniževati proti ničelni stopnji.

Za analiziranje učinkov staranja prebivalstva na učinkovitost monetarne politike uporabim primerjavo dveh modelov, ki se razlikujeta v starostni strukturi. Prvotni model ima stopnjo starejšega prebivalstva enako 70%, drugi pa zgolj 25%. Iz primerjave impulzivnih odzivov spremenljivk na zaostrovani šok denarne politike ugotovim, da bo staranje prebivalstva vplivalo na bolj negativni odziv potrošnje delavcev in hujše deflacijske pritiske na ekonomijo. Prav tako v primeru potrošnje upokojencev pride do manjše reakcije njihove potrošnje v primeru mlajše populacije, medtem, ko se odziv

obrestne mere na šok med populacijama ne razlikuje. Zanimivi rezultati so predvsem na področju proizvoda, kjer za izračunano proizvodno vrzel na delavca ugotovim, da se le ta v primeru starejšega prebivalstva lahko nagne v pozitivno smer.

Rezultati magistrske naloge, so glede na izračunan model in primerjavo modela med dvema populacijami z različno starostno strukturo sledeči. Staranje prebivalstva vpliva na večje deflacijske pritiske v ekonomiji, hkrati pa negativno vpliva na proizvodnjo na delavca in vpliva na večje odziv obeh potrošenj v ekonomiji. Zaradi predstavljenih učinkov staranja prebivalstva na makroekonomske spremenljivke, bo moč zaznati večje znižanje razmerja žrtvovanega razmerja med proizvodnjo in inflacijo, kateremu bo sledila denarna politika. Denarna politika bo zaradi učinkov staranja prebivalstva izgubila moč vplivanja na proizvodno vrzel, veliko omejitev pa se lahko pojavi tudi pri vplivanju denarne politike na inflacijo. Iz vseh tega namreč sledi, da bo staranje prebivalstva oslabilo delovanje denarne politike, prav tako pa se bo znižala tudi njena učinkovitost. Skladno z dokazi je torej velikega pomena, da se učinki staranja prebivalstva na denarno politiko in njeno učinkovitost analizirajo takoj, saj je le tako mogoče zmanjšati te negativne učinke. Oblikovanje nove denarne politike, ki bo bolj prilagojena spremenjenim navadam starejše populacije, bo tako odločilnega pomena pri minimiziranju negativnih učinkov na celotno makroekonomsko situacijo in tudi na učinkovitost številnih makroekonomskih politik, kot sta na primer denarna in fiskalna politika.

Appendix 2: Preference parameters of model variables

Table 4: Preference parameters values

Parameter	Name	Value
φ	Old-age dependency ratio	0.25 and 0.7
σ	Intertemporal elasticity of substitution	2
ψ	Elasticity of labor supply	1
β	Discount factor	0.99
μ	Mark-up	1.2
θ	Price stickiness	0.75
Φ_π	Feedback parameter of inflation	1.4
Φ_x	Feedback parameter of output gap	0.13
ρ_v	Persistence of monetary policy shock	0.3

Source: Own work.